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THESIS

THE USE OF COLOR IN THE OUTPUT ANALYSIS
OF STATISTICAL SIMULATIONS, AND ANALYSIS
OF ESTIMATORS OF SERIAL CORRELATION

by

Robert L. Youmans

September 1988

Thesis Advisor:

Peter A. W. Lewis

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The Use of Color in the Output Analysis
of Statistical Simulations, and Analysis
of Estimators of Serial Correlation

by

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Captain, United States Army
B.S., Francis Marion College, South Carolina, 1980

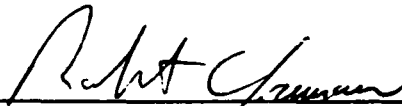
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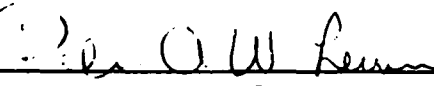
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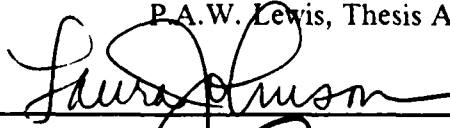


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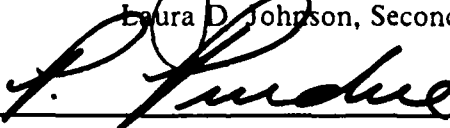
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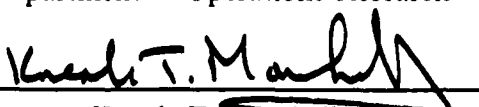
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ABSTRACT

The use of color in the organization and analysis of the output of multifactor statistical simulations is investigated with the computer package SIMTBED (A Simulation Test Bed). Updating of this system to the current technology of color line printers is performed. It is shown how color can be used to code some factors in a multifactor simulation, compacting the output and enhancing analysis. An application to the analysis of the lag one serial correlation of normal and non-normal time series using four estimators (moment, maximum likelihood, robust regression, and the Cressie estimator) is provided as a demonstration of the uses of SIMTBED in statistical simulations. These estimators are examined for robustness and asymptotic bias, as well as relative behavior with various sample sizes. It is shown that for some time series the robust estimators of serial correlation are not acceptable due to bias and other considerations.



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I. INTRODUCTION

This thesis consists of two parts: the analysis and updating of an existing computer simulation package to include the use of color in output analysis, and an application using the simulation methods in the analysis of robust estimators of serial correlation for time series. The technology of computers, especially the personal computer (PC), and the ability of the academic (as well as the user) community to perform computer-assisted simulations is rapidly changing, and this work represents an effort to use more modern methods and equipment in computer simulations, such as color printers and the faster personal computers. This allows more compact output analysis of the results of multi-factor simulations, through the use of color to code some of the parameters of the simulation experiment. Through the use of color, a direct graphic comparison of the behavior of different estimators in a statistical simulation can be made, enhancing the output analysis.

The research community has provided several methods for assessing autocorrelation that warrant further research, and the application of this simulation package to some of these methods seems appropriate. Specifically, some autocorrelation estimators purported to be robust are evaluated when applied to time series with various marginal distributions, including the Normal and other non-Normal distributions, and their behavior is compared. These results should prove useful to any student or researcher interested in either performing statistical simulations, or the estimation of autocorrelation parameters, for example in the examination of oceanographic data, or positions of shells on successive firings of an artillery piece. Serial correlation is of interest in the study of learning phenomena, such as accuracy of a rifleman in subsequent shots at a target. It is also used to study the independence of the individual members of a sample, to support assumptions of independence. In these situations the estimator of serial correlation used may be important.

The remaining chapters of this thesis discuss multi-factor statistical simulations, the FORTRAN simulation package SIMTBED (SIMulation Test BED) and its updating, and application to the estimation of serial correlation. With the pace of technology and research today, there is always a need for more effort to move existing systems into the current and future technology. As our abilities to conduct these types of experiments

improve, so will our understanding of the theoretical processes involved, and their application to the real world through research.

II. MULTI-FACTOR STATISTICAL SIMULATIONS

In their text on simulation methodology, Lewis and Orav [Ref. 1, p. 1-2] describe a simulation as a controlled statistical sampling technique, and a controlled statistical experiment. This is to be contrasted with real-world statistical sampling, in which the statistician has no control over the population being sampled.

A. PURPOSE.

The purpose of a statistical simulation is therefore to assess some property of a statistical estimator of a parameter in an i.i.d. sample or in a random process (time series). These simulations are generally applied to situations where the processes being considered have no good analytical form to study. When there are multiple estimators, simulation can facilitate choice among them, given some criteria by which a comparison can be made.

B. EXAMPLES.

Examples of statistical simulations include:

- A study of the Student's t statistic applied to non-Normal random samples. Here, there is no good analytical result for the behavior of the statistic. A comparison can be made with the behavior of the t -statistic as applied to Normal samples.
- A study of various trimmed means (say, 5%, 7%, 10%), and their behavior compared to the arithmetic mean, for different distributions and sample sizes.
- A study of sampling, with replacement, from a generated population, and the study of the sampling distribution of a statistic (say, the median), for different distributions.
- Comparison of the Maximum Likelihood Estimator (MLE) with the Moment estimator for various statistics.
- Large sample studies of the asymptotic behavior of some statistic (i.e., higher moments, like skewness or kurtosis).
- A study to analyze the variability of some statistic, when there is no good analytical result (such as the variance of the coefficient of variation) for different distributions.

C. CONSIDERATIONS.

In all of the examples and applications of statistical simulations the following considerations are implied:

1. Factors.

Several factors are involved in the simulation. These can be the different estimators under study, the type of distribution involved in the study, some parameter variation on the distribution, the sample sizes involved, or any combination of these. The simulation experiment is to be repeated for each of these factors, and the output must be analyzed in an organized manner to examine the effect of varying these factors.

2. Replications.

There is to be some repetition of the statistical simulation to assess variability information. Random processes are involved, and repetition is required to observe behavior with any degree of assurance. Sometimes the amount of repetition required to gain an acceptable variability in the results is unknown at the start of the simulation.

3. Resources.

These experiments can be complex to conduct. Combined with the factors involved, a significant computing resource can be involved. A mainframe can provide computing power in terms of speed, but at a cost. Personal computers, while possessing much less speed, can accomplish similar tasks, with more time required, but the cost can be much less, especially considering the availability of the personal computer versus the mainframe. In any case, the user must often write some part of the routines that produce the simulation. This can include the driver routine, which generates the random process and calculates the values under study, or it could include the entire simulation, including the graphics and other output routines. The best approach is to have available some package which can take user driver routines and then aggregate the output from them into a compactly presented output, so the user can focus on the aspects of the simulation (i.e., the process and the results). This is the approach of SIMTBED.

D. OUTPUT ANALYSIS.

Consider the following example. We wish to study the behavior of four estimators of serial correlation (autocorrelation), specifically applying these estimators to samples from first order autoregressive processes whose marginal distribution is the standard Normal distribution, and with four other first order autoregressive processes with non-Normal marginal distributions. We wish to study, say, eight sample sizes, from 20 to 5000, and we want to know how these estimators behave when the true values of the serial correlation take values of -0.9, 0.9, and 0.0. Since we know the correlations of the random samples we generate, we can compare these estimators to each other, and also to the known values of the correlation. The number of simulations required to provide

only one realization of our estimators for each consideration is clearly the product of the number of each of the factors, or 480. This would be an intractable process without some organized approach to perform some of these runs as a batch. Further, in order to assess the variability in these results we wish to repeat the entire overall simulation a number of times. Not only does this represent a significant computing requirement, but some type of compact organization of the output is required for analyses and comparisons to be possible.

1. Graphics.

Graphical displays can portray a great deal of information clearly, quickly, and in a compact manner. We can use graphics and graphical symbols to combine the location and variation measures, like a boxplot, and we can plot related data close together for quick comparison. The repetitions performed to introduce stability (precision) into the simulation can be combined into the boxplot-type graph, with tables attached for reference. This represents only one way to approach output analysis, and the exact methods used depend on the simulations being conducted. For example, if we are comparing an estimator's behavior under different distributions, we would like a graphical representation which depicts each distribution's results together, so differences will be apparent. This graphical approach, combining several of the factors of the simulation in one plot, is the approach taken to output analysis with SIMTBED.

2. Regression and Asymptotic Behavior.

There are many statistical estimators in the literature with claimed asymptotic behavior with respect to sample size. Indeed, Cramer proves that any central moment of a sample of any population is asymptotically normally distributed, and he gives the mean and variance as functions of n , the sample size [Ref. 2, p. 365]. If we are interested in demonstrating asymptotic performance (say, for different distributions), we would want the estimator plots arranged by sample size to show trends. Of interest might be the sample size at which the asymptotic normal behavior of our estimator is apparent, which might allow all types of analysis possible for normally distributed data (confidence intervals, etc.). More likely, though, we are interested in the value of our estimator, suitably unbiased, which is approached as the sample size gets very large. In this situation, regression can be applied. Lewis and Orav present the results of the geometric expansion for the mean and variance of central moment estimators (the delta method), and further states that these results also apply well to estimators that are not functions of central moments [Ref. 1, p. VI-35]. In equation form, these results are:

$$E(\theta_m) = \theta + \left(\frac{a_1}{m}\right) + \left(\frac{a_2}{m^2}\right) + \left(\frac{a_3}{m^3}\right) + \dots \quad (2.1)$$

$$\text{Var}(\theta_m) = \left(\frac{b_1}{m}\right) + \left(\frac{b_2}{m^{1.5}}\right) + \left(\frac{b_3}{m^2}\right) + \left(\frac{b_4}{m^{2.5}}\right) + \dots \quad (2.2)$$

where a 's and b 's, are constants, m is the sample size, and θ is the value of the estimator. Notice in equation (2.1) that the first term is the asymptotic value of the estimator θ itself. So, if we perform a regression using these equations and the appropriate powers of the sample size, we can attain a value and variance for the estimator as it behaves asymptotically. This regression is the type implemented in SIMTBED. With repetitions of our simulations we can observe the variability of the coefficients of the regression. Observe that more sample sizes in the simulation design allow an increased degree of regression, where by degree we mean the number of terms of equations (2.1) and (2.2) used, which typically have to be truncated to, say, four or six terms.

E. HUMAN FACTORS AND INFORMATION CODING.

When referring to information coding, we mean that the original information has been converted to a new form, and displayed symbolically, as discussed in the human factors industry [Ref. 3, p. 50]. In our output analysis, there are two forms of information coding.

1. Graphics.

The measures of location and spread for the statistical estimator have been converted to a graphical representation, the widely used boxplot. This allows rapid comparison of different runs (estimators, sample sizes, etc.) based on location and spread. Tables are also used, for detailed reference, if needed.

2. Simulation Factors.

In the update to SIMTBED as part of this thesis, the different estimators will have their identity coded by color, so that when plotted together, two estimators that otherwise have identical simulation factors (sample size, distribution, and parameters) will be distinguished by color for comparison. Further, as a consequence of the simulation processing, these estimator plots will also be coded by their position in the graph, which is not a good form of coding. Sanders and McCormick compare these coding dimensions (color and position) and others, and conclude that color is the best (in terms of correct responses), and position is the worst (configuration is the term used by these authors for position coding) [Ref. 3, p. 98]. Nonetheless, this makes it possible to use

these comparisons on any personal computer with a dot matrix printer, which SIMTBED uses for output, as well as the newer color dot matrix printers. This direct comparison of estimators in a simulation is an addition to the capabilities of SIMTBED.

The stage is now set to discuss the statistical simulation package, SIMTBED, as updated by this thesis, its capabilities, limitations, and method of use. Before doing this we note that the philosophy on the design of the original SIMTBED was to use line printer graphics for portability. This goal can still be achieved if color is included in the output graphics and the widely available and cheap dot-matrix printers are used for SIMTBED output.

III. SIMTBED.

This chapter discusses the package SIMTBED, in currently available versions, and the enhanced version created in this thesis (version 13). We discuss the SIMTBED approach to statistical simulation, the output organization it uses, and the updating to the use of color as a SIMTBED enhancement. For a detailed description of the details required to actually run SIMTBED, see Appendix A. Appendix A is designed to function as a user's guide for this version of SIMTBED.

A. DESCRIPTION.

SIMTBED is a collection of FORTRAN subroutines that perform the detailed output analysis for statistical simulations. The user writes a driver program that provides the necessary parameters of the simulation, and calls the SIMTBED subroutine. The user also provides the routines that generate the random process and calculate the statistics of interest. SIMTBED performs a sectioning of the sample sizes the user specifies and determines the number of calls required to each generating routine to produce the desired result. It then prepares all the plots and output statistics from the data supplied by the generating routines. In this way, the user focuses on the process involved in his simulation, and on the output he receives, and is relieved from the organization and generation of the output itself. This present version (13) of SIMTBED is designed to run on the IBM PC/AT family of personal computers, when compiled by any of the currently popular FORTRAN compilers. The update to older versions of SIMTBED that produced this version (13) includes the capability to produce combined plots of the user-supplied estimators, in color, and an increase in the number of estimators SIMTBED can process. The older versions could only process three estimators. The graphics used by SIMTBED, called line printer graphics, uses the dot matrix printer and its characters, in compressed-type mode, to produce the plots.

B. HISTORY.

SIMTBED originated with a mainframe version written by Lewis, Orav and Uribe in 1981. This was ported to and improved upon in a PC version in a Naval Postgraduate School Thesis by Hans-Walter Drueg [Ref. 4]. In this work, Drueg produced the first PC version of SIMTBED, with applications to statistics. His work was based on the regression methods of Lewis and Heidelberger [Ref. 5] and the graphical approach used

by Linnebur in the program RAGE [Ref. 6]. Since then, numerous updates have been incorporated by the Naval Postgraduate School simulation community, most notably by L. Uribe, and P. A. W. Lewis. Updates to SIMTBED include:

- Addition of percentile and quantile plots for each estimator.
- Computation of Mean Squared Error (MSE), when known values are input.
- Bivariate histograms to show relationships between pairs of estimators with respect to sample size.
- Super-replications to provide precision/variability information on all the SIMTBED statistics.
- A restart capability for long simulations, allowing a simulation to be performed as a series of super-replications, with each series building on the ones before.
- Most recently, the use of color printers to provide combined plots of estimators (the work of this thesis).
- Even more recently, a mainframe version utilizing laser printer technology, with even more capability (restricted to mainframe use).

Appendix D, the SIMTBED source listing, has comments at the beginning which also portray the historical development of the program.

SIMTBED has been incorporated into the Advanced Statistical Package, a published software package from P. A. W. Lewis (as SMTBPC). The manual from that package has been used in courses in simulation at the Naval Postgraduate School [Ref. 7].

C. THE APPROACH OF SIMTBED.

SIMTBED views each estimator (represented by a generating subroutine passed to SIMTBED with all other parameters) as a separate simulation run, and performs all the analysis on each estimator in turn (see Figure 1.). The capability added with this thesis consists of the color combined plots at the end of the SIMTBED processing. (Refer to Appendix B for a discussion of the programming aspects of color printing with SIMTBED.) If combined color-coded plots of up to five estimators are requested at the completion of the simulation experiment, the data needed from each estimator's simulation is kept until the end for preparation of the combined plots. Otherwise, each estimator is completely processed in sequence. Up to five estimators can be processed in one run of SIMTBED (each represented by a generating subroutine). This is an improved capability in that more estimators can be studied, and the results can be compared at the finish, graphically, in color.

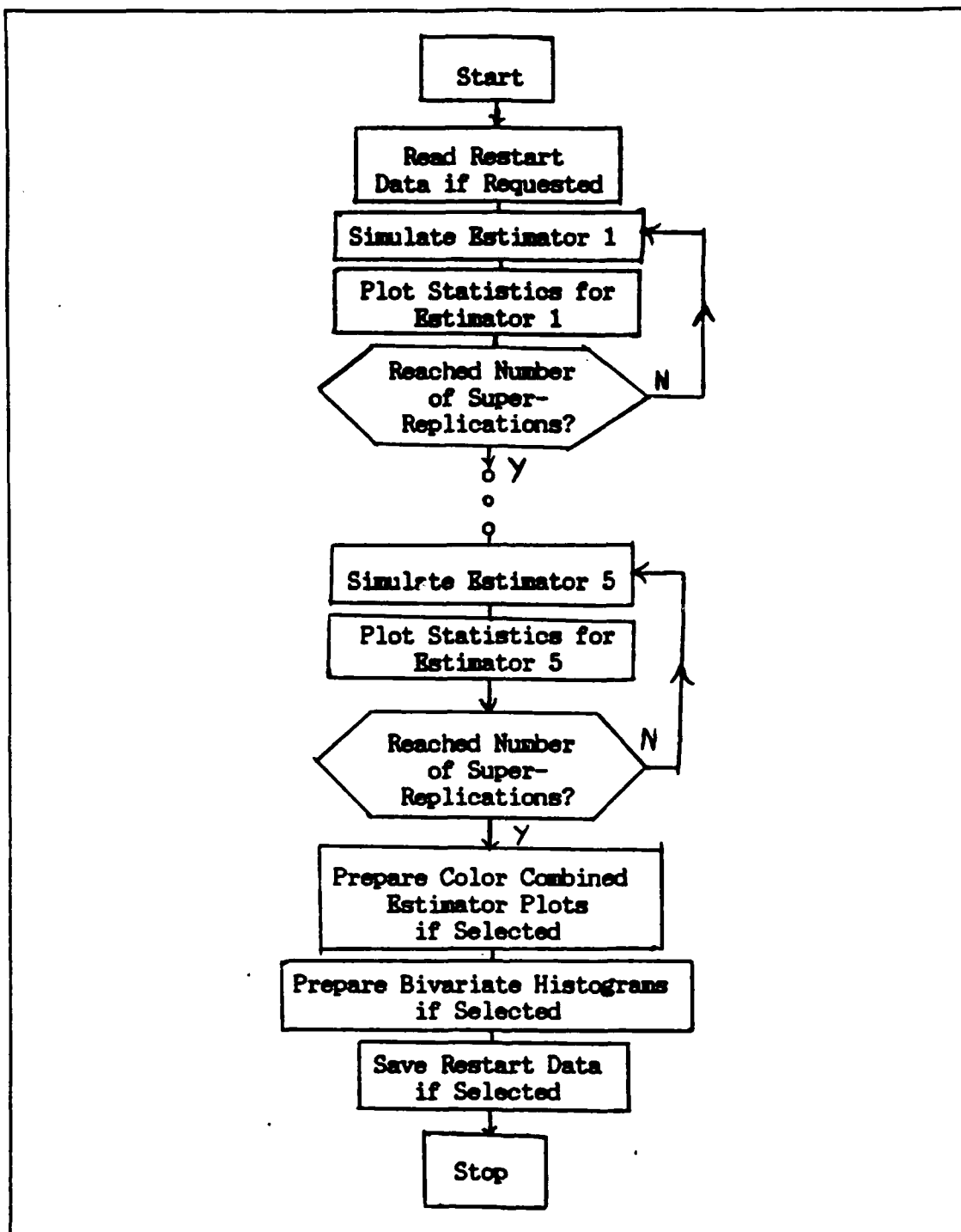


Figure 1. SIMTBED Processing Flowchart

1. Sectioning to Conduct Simulations.

a. *Major parameters description.*

In addition to routine parameters (number of estimators, subroutine names, etc.), SIMTBED must have information on the sample sizes that are to be used for the estimators, i.e., the sample sizes for which the properties of the estimator are to be examined. These are referred to as "sub-sample sizes," because the "sample size" refers to the global sample size from which each of the sub-samples is sectioned. We use "N" to represent this global sample size, and "NE(*)" to represent the sub-sample sizes, since they are passed in an array (from 1 to 8 sub-samples are possible). Further, a number of replications of each sub-sample size may be performed, in order to observe the variability in the regression performed on the values of the estimators (see Chapter 2, Section D.2). This is denoted by "M". These are the three major parameters affecting the simulation. The global sample size N is a function of the available memory of the machine being used.

b. *Performing a simulation by sectioning.*

Consider this example. Given a sample size, N, of 5000, a replication value, M, of 20, and a sub-sample size, NE(1), of 20, SIMTBED will proceed as follows. The sample space for the 5000 values of data from which the estimators can be computed will be divided up into groups of size 20, so there will be $(5000/20) = 250$ evaluations of the estimator, each based on a separate, independent sample of size 20. This will be repeated M times, so there will be 5000 evaluations of the estimator, based on a sample of size 20. This is the way SIMTBED sections to produce the necessary number of evaluations based on the desired sample size. Machine memory storage must be available for $(N \times M) \cdot NE(1)$ variables in an array.

This process is independent of the estimator subroutine. For example, if our estimator were the coefficient of variation of an exponential(λ) distribution, SIMTBED would call that routine 250 separate times, and pass a new sample size of 20 from which to compute the estimate of coefficient of variation. The data generator routine would generate the random variables and compute the coefficient of variation. This process would repeat for each of the other (as many as eight total) sub-sample sizes, and if requested, a regression would be performed on the means of each of the sub-sample realizations of the estimator. This regression process is replicated M times to estimate the variability of the regression coefficients. See Chapter 2, Section D.2, and Appendix A for more on the regression performed by SIMTBED.

2. Super-Replications.

As each estimator is processed it turn, it is possible to perform the entire sectioning process for that estimator a specified number of times. These are referred to as super-replications, and allow the experimenter to evaluate variability and precision information about all of the results presented for one iteration of the simulation process. For example, one replication will yield a single value of the asymptotic expected value of the estimator being simulated (from Equation 2.1). The number of replications specified in the simulation allow estimating the spread of these coefficients of the regression, but still only one value is obtained. To obtain more realizations of this expected value, super-replications can be performed, and then tests for normality (i.e., quantile plots, etc.) can be performed for validity. These super-replications, being independent, should be normally distributed about the true estimator value, from the central limit theorem. SIMTBED performs these super-replications as specified by parameters when SIMTBED is called. All super-replications for one estimator are performed before the next estimator in the chain is processed. It is possible to obtain repeated output graphs for the first three of these super-replications, to check the simulation; thereafter, SIMTBED generates a summary table and optionally a normalized quantile plot (see section D).

3. Combined Plots in Color.

At the completion of simulation for all estimators, a plot of some of the information from each estimator in the chain that was processed can be generated. This amounts to plotting together some of the boxplots describing each estimator, with each a different color, aiding comparison of the behavior of the estimators relative to each other. While not a substitute for comparing tabulated values (such as mean squared errors, standard deviations, and means), this type of graphical comparison can provide meaningful information that could otherwise be hidden in the tabled values of the output. Analysis of the large volume of output produced in these types of simulations is thus aided by these types of graphical comparison, which can provide a wealth of information at a glance.

4. Restart and Other File Operations.

Due to the lack of good analytical form for the behavior of the estimators in these types of simulations, the amount of repetition (super-replications) required to get a specified degree of precision (with respect to asymptotic performance) or a low enough variance (say, in the mean value) may not be known until it is reached. Rather than keep repeating the simulation with larger and larger parameters, SIMTBED will use data

files to store the results of the super-replications, and subsequent super-replications can use the results from previous runs as though they had just been obtained. This allows the user to 'build up' his simulation until the values obtained have the needed precision, or until the required convergence/divergence or bias is seen. It may also be useful to have these results for processing by another package, or for record-keeping. SIMTBED can also perform this function with an output file. Refer to Appendix A for the actual use of these features.

5. A Variance Reduction Technique.

One popular technique that can be used to reduce the variability in the results of a statistical simulation is to use the same random number stream for each estimator in the simulation [Ref. 1, p. VII-24]. Thus, each estimator operates on the same series of random numbers, instead of on separate streams of random numbers, and the variability between different estimators that would be introduced by differing random number streams is reduced to only the variability introduced by the behavior of the estimators, as they are applied to the samples through the sectioning and replication process. This is accomplished in SIMTBED with the random number seeds used to begin the generation of the pseudo-random numbers (see Appendix A for a detailed description of the SIMTBED parameters).

D. SIMTBED OUTPUT AND STATISTICS.

1. The Basic SIMTBED Plot.

Figure 2 represents the basic SIMTBED plot, a series of boxplots for each sub-sample size, representing the simulation for one estimator.¹

Included in the boxplot for each sub-sample size are $(M \times N)/NE$ evaluations of an estimator. If regression is performed, the regression asymptote is also plotted. To facilitate plotting the regression line, the sub-samples are placed according to their value (i.e., the axis is scaled based on the sub-sample values). The following statistics are listed in tabular form for each sub-sample size: the first four central moments, the standard error of the mean, and (optionally) the mean squared error. The coefficients of the regression equation are also listed. The estimator name appears at the bottom of the plot.

a. An Example of Generating the Estimators.

In the example of Figure 2, we have generated Normal, AR(1) (autoregressive) time series with mean zero and variance 4, and the successive values of the time series are

¹ These plots have been reduced for enclosure in the thesis. They are normally full-sized.

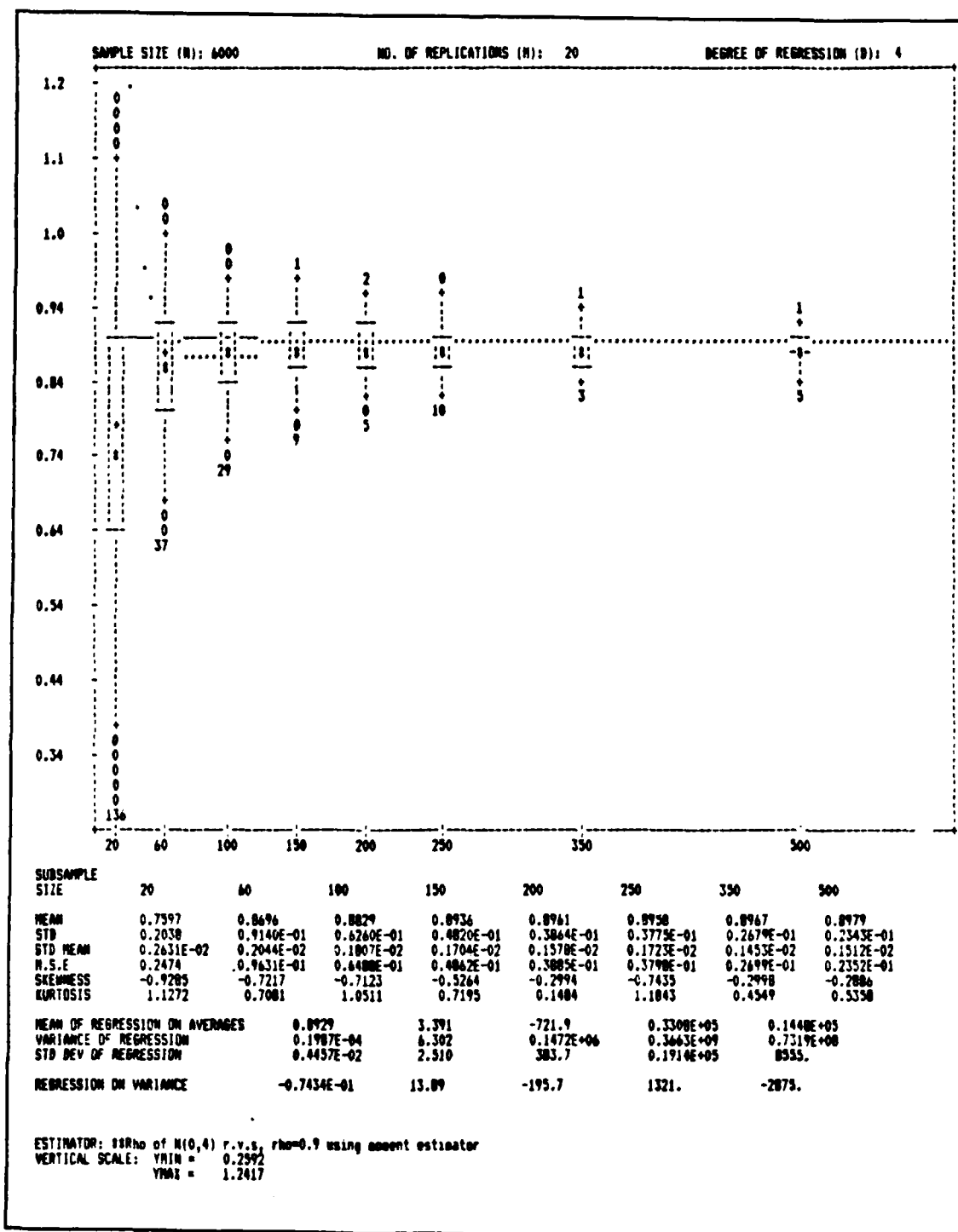


Figure 2. Sample SIMTBED Simulation.

correlated with correlation coefficient $\rho = 0.9$. The estimator is the familiar moment estimator of serial correlation:

$$\hat{\rho} = \frac{\sum_{i=1}^{NE-1} (x_i - \bar{x})(x_{i+1} - \bar{x})}{\sum_{i=1}^{NE} (x_i - \bar{x})^2},$$

where \bar{x} is the mean of the NE observations in the estimator.

Thus, we know the properties of the generated random number stream and we are observing the behavior of the estimator $\hat{\rho}$. Figure 2 shows that the simulation was performed for each of 8 subsample sizes, ranging from 20 to 500, and 6000 random variates were used to simulate each subsample size, and this was repeated 20 times to assess the precision of the regression coefficients. So, for example, for subsample size 100, the number of evaluations of $\hat{\rho}$ is given by:

$$\frac{6000 \times 20}{100} = 1200$$

These 1200 evaluations of $\hat{\rho}$ were obtained by proceeding as follows. The sample space of 6000 generated data values of the time series is sectioned into batches of size 100 (the subsample size in this example). For each section, one value of the estimator is computed. This sectioning is then replicated 20 times ($M = 20$), which yields $60 \times 20 = 1200$ evaluations of the estimator at subsample size 100. From Figure 2, the values of the moments computed below the column labeled '100' are thus based on 1200 evaluations of $\hat{\rho}$.

b. Subsample Statistics.

Continuing with subsample size 100 as an example from Figure 2, the mean, standard deviation, standard deviation of the mean, mean squared error, and the higher moments (coefficients of skewness and kurtosis using unbiased expressions) are computed, using all 1200 evaluations of $\hat{\rho}$. The theoretical standard error of the correlation estimate can be seen to follow the behavior given by:

$$\text{S.D. MEAN} = \frac{\text{sample S.D. of the estimates of the correlation}}{\sqrt{n}},$$

where here n is the total number of estimates of serial correlation used. For subsample size 100, the standard deviation of the average of the 1200 estimates of the serial correlation is estimated from the standard deviation of the 1200 computed values of serial correlation. This gives

$$\frac{.06260}{\sqrt{1200}} = 0.001807.$$

Thus the mean value of the estimate of $\hat{\rho}$, namely 0.8829, is more than two estimated standard deviations from the known true value $\rho = 0.9$, indicating that the estimator is still biased at sample size 100.

The mean squared error (MSE) is used in this simulation since we know the value of the estimator under study for the sample we generated, i.e., we created the random number stream with a correlation of 0.9. We can thus measure how the estimator deviates from this value, still considering its inherent variability, by using the mean squared error given by²

$$\text{MSE} = \sqrt{\text{VAR}(\bar{\rho}) + (\bar{\rho} - \rho)^2},$$

where $\bar{\rho}$ is the average of all the estimates $\hat{\rho}$ of serial correlation (the estimator under study in this example), ρ is the known true value of the serial correlation of the time series, and $\text{VAR}(\bar{\rho})$ is the sample variance of the estimates of serial correlation (there are 1200 of these for sub-sample size 100 in this example). This expression is realized by considering that the variance of the realized values of the estimators (serial correlation) is the second central moment about the expected value of the estimator ($E(\hat{\rho})$), usually estimated by $\bar{\rho}$, i.e.

$$\text{VAR}(\hat{\rho}) = E(\hat{\rho} - E(\hat{\rho}))^2 = \frac{1}{n} \sum_{i=1}^n (\hat{\rho}_i - \bar{\rho})^2,$$

where $\hat{\rho}$ represents the estimated value of the statistical estimator under study (i.e., serial correlation in the example), and $\bar{\rho}$ represents the average of all the observed values of $\hat{\rho}$. The expected value of the estimator, $E(\hat{\rho})$, may in fact be biased, and not at all

² Formula from SIMTBED source code.

approach the true value ρ . So, the Mean Squared Error is used, as the expectation of the values of the estimator, $\hat{\rho}$ about the true value ρ . Thus,

$$MSE(\hat{\rho}) = E(\hat{\rho} - \rho)^2.$$

This Mean Squared Error can be thought of as consisting of two parts: the variation of the evaluated estimators about their average (their expected value), and the variation of this expected value about the true value ρ . Mean Squared Error then becomes

$$MSE(\hat{\rho}) = VAR(\hat{\rho}) + (bias)^2,$$

with the 'bias' term representing the difference between the expectation of the estimator, $E(\hat{\rho})$ and the true value ρ , giving

$$MSE(\hat{\rho}) = VAR(\hat{\rho}) + (E(\hat{\rho}) - \rho)^2.$$

Now, using $\bar{\rho}$ to estimate the expected value of the estimator (serial correlation in the example), $E(\hat{\rho})$, and computing the expected value from the evaluations of serial correlation gives the formula for computing the estimated Mean Squared Error,

$$\hat{MSE}(\hat{\rho}) = \left[\frac{1}{n} \sum_{i=1}^n (\hat{\rho}_i - \bar{\rho})^2 + (\bar{\rho} - \rho)^2 \right]^{\frac{1}{2}}$$

This becomes

$$\hat{MSE} = \sqrt{(VAR(\hat{\rho}) + (\bar{\rho} - \rho)^2)}$$

giving the formula used for mean squared error.³

If the known values of the estimator are not available for the simulation, MSE is not used (SIMTBED parameter entries).

c. *Regression.*

Part of the tabled information of Figure 2 includes the regression coefficients, as discussed in Chapter 2. When replications are performed, the variance and standard deviation of the regression coefficients for the regression on the means of the estimator is supplied. In this example, the degree of regression (the number of terms of

³ From analysis with thesis advisor.

equations 2.1 and 2.2 to be used) is 4, and the regression coefficients can be observed. Note that if the number of subsamples in the simulation is too small (eight is a maximum, not the required number), SIMTBED will not perform regression. The first value listed in the "mean of regression on averages" line in Figure 2 is the estimated asymptotic value of the estimator, given by this simulation. Since the estimate of this asymptote is 0.8929 and the true value is 0.9, the difference is 0.0071. The estimated standard deviation of the estimate of 0.044 (line labeled "std dev of regression"). Thus the estimate 0.8929 is within 2 (estimated) standard deviations of its true value

Note that if super-replications were performed we could obtain several evaluations of this asymptotic value, as well as its average over the number of super-replications performed.

d. Boxplot Graphics.

For each subsample size, a boxplot is provided which displays the location and spread behavior for all the evaluations of the estimator obtained for that subsample size. Continuing with the current example, for subsample size 100, then, 1200 values of $\hat{\rho}$ are incorporated into that particular boxplot. In Figure 2, the boxplots are constructed using reduced graphics, which means the extreme outliers are counted and displayed at the ends of the boxplot, rather than actually plotted, which would occupy valuable scaling space on the plot. This way, the majority of the space is devoted to the location measures (mean and median) and the spread measure (inter-quartile range) for the graph. The asymptote and regression lines are also included when regression is performed. This way, the behavior of the estimator can be observed with regard to sample size. In Figure 2, it can be seen that the moment estimator indeed has some bias at the lower sample sizes, but that the bias disappears as sample size increases. For further analysis the user can select the subsample sizes which will be plotted together for *all* the estimators in the simulation in the combined color plot at the end of the simulation run. Also of note is that this boxplot graph is only one realization of the data that is incorporated into super-replications. Up to three consecutive plots like Figure 2 can be prepared when super-replications are used, each an iteration itself.

2. Quantile Plots.

Figure 3 depicts the second SIMTBED plot produced as each estimator is processed. It consists of the empirical quantiles of the estimator at each subsample size, with each quantile represented by a symbol. A table below the plot lists the actual values. This plot can be seen to correspond exactly with the boxplots of Figure 2. It is

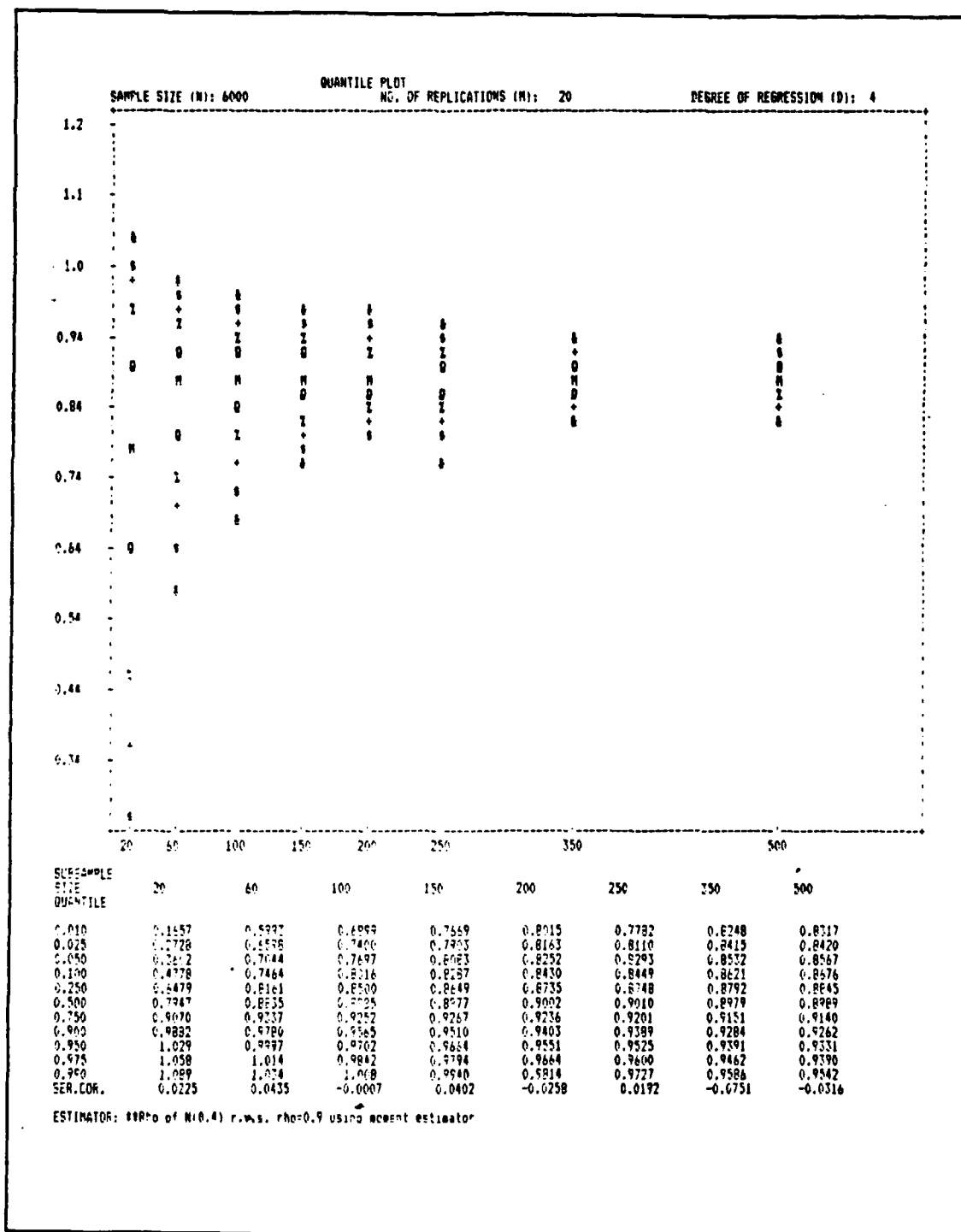


Figure 3. Sample SIMTBED Quantile Plot.

merely a more detailed representation of the data. Here, the tails of the estimator distribution can be examined for symmetry, etc.

3. Super-replications Output.

When super-replications are used, a summary quantile plot, like that in Figure 4, is prepared, along with a tabulated summary (Figure 5). Figure 4 is an example super-replication quantile plot. This plot is rather self-explanatory, beyond the fact that it consists of the quantiles of each iteration of the basic SIMTBED plot discussed above. In other words, in Figure 4, there are three values of the 0.5 quantile averaged and plotted with an 'M'; these quantiles are part of the table of summary statistics for all super-replications, an example of which appears in Figure 5. Note here that all the statistics included in the basic plot are present, and that each has an associated standard deviation, obtained by repeating the entire simulation experiment. This procedure can be carried on indefinitely by the use of the restart facility. When restart is used, the previous values are saved in a file, and all previous data is used to prepare the most recent super-replications summary table and plot. Referring to Figure 5, we can see the mean of regression on averages entry, which is a list of the regression coefficients, and we see the moment estimator asymptotically tending to 0.8991, which would indicate asymptotic unbiasedness for this estimator, given that the largest sample size used was 500, and the number of super-replications used here was 3. This would indicate convergence to the known value of 0.9 for this estimator. In the next chapter we will see the behavior as the super-replications are carried out much further.

4. Color Combined Estimator Plots.

After the simulation run has proceeded through all super-replications of as many as five statistical estimators, we may be interested in how the estimators compare to each other. This plot was incorporated into SIMTBED for that purpose. Figure 6 is an example of four estimators of serial correlation, all plotted together, for three of the eight subsample sizes of the simulation. Note that the group of boxplots (each containing four boxplots, one for each estimator) is positioned with respect to the second one in the group. Note also that the plots are coded dually, as discussed in Chapter 1, Section E. That is, they are coded by color and position. The names of the estimators appear at the bottom of the plot. Estimator 1, the robust least squares approach to serial correlation, is the first in each group for the three subsamples. All estimators are applied to the same distribution and their behavior can be directly compared. Referring to Figure 6, one can observe that for small sample sizes, the robust least squares estimator has the best behavior in terms of bias. Note that the samples come from the

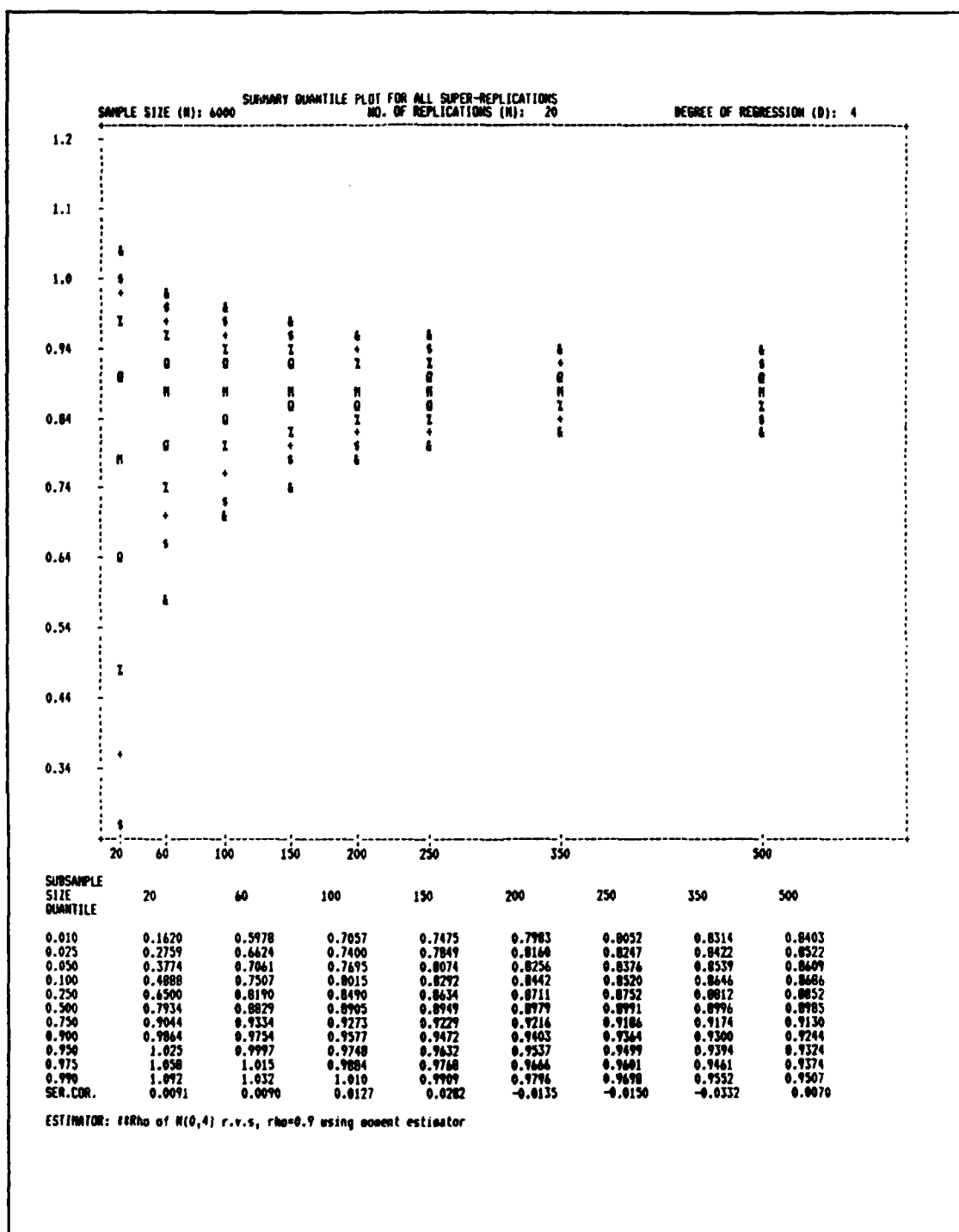


Figure 4. Sample SIMTBED Super-replication Quantile Plot.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	3 SUPER-REPLICATIONS							
	20	60	100	150	200	250	350	500
MEAN	0.7604 0.5710E-03	0.8704 0.4679E-03	0.8848 0.9913E-03	0.8910 0.1650E-02	0.8950 0.6414E-03	0.8964 0.3123E-03	0.8986 0.9754E-03	0.8979 0.2670E-03
STD	0.2006 0.1752E-02	0.9064E-01 0.3779E-03	0.6238E-01 0.6536E-03	0.4781E-01 0.8968E-03	0.3833E-01 0.4998E-03	0.3383E-01 0.2801E-02	0.2615E-01 0.8946E-03	0.2171E-01 0.8577E-03
M.S.E	0.2444 0.1629E-02	0.9534E-01 0.4985E-03	0.6420E-01 0.7706E-03	0.4878E-01 0.1049E-02	0.3867E-01 0.5250E-03	0.3402E-01 0.2014E-02	0.2623E-01 0.9125E-03	0.2181E-01 0.8533E-03
SKEWNESS	-0.9392 0.2681E-01	-0.8485 0.6510E-01	-0.6380 0.3722E-01	-0.5723 0.2599E-01	-0.2992 0.7093E-01	-0.3789 0.1943	-0.3630 0.1150	-0.2804 0.6242E-01
KURTOSIS	1.246 0.1107	1.481 0.3985	0.7619 0.1447	0.9390 0.1098	0.2828 0.8507E-01	0.5704 0.3886	0.1447 0.2563	0.1808 0.2592
SER.COR.	0.9131E-02 0.1472E-01	0.8963E-02 0.1940E-01	0.1268E-01 0.1598E-01	0.2818E-01 0.1293E-01	-0.1351E-01 0.1253E-01	-0.1500E-01 0.2025E-01	-0.3321E-01 0.4708E-01	0.7040E-02 0.2130E-01
QUANTILES								
0.010	0.1620 0.1123E-01	0.5978 0.1482E-02	0.7057 0.7951E-02	0.7475 0.1143E-01	0.7983 0.1652E-02	0.8052 0.1382E-01	0.8314 0.5055E-02	0.8403 0.4830E-02
0.025	0.2759 0.4175E-02	0.6624 0.1712E-02	0.7400 0.1839E-02	0.7849 0.3250E-02	0.8160 0.5319E-03	0.8247 0.6870E-02	0.8422 0.3525E-02	0.8522 0.5105E-02
0.050	0.3774 0.8658E-02	0.7061 0.1082E-02	0.7695 0.2315E-02	0.8074 0.3591E-02	0.8256 0.2214E-03	0.8376 0.4357E-02	0.8539 0.6690E-03	0.8609 0.2132E-02
0.100	0.4888 0.5519E-02	0.7507 0.2195E-02	0.8015 0.1647E-02	0.8292 0.2308E-02	0.8442 0.7577E-03	0.8528 0.3610E-02	0.8646 0.1393E-02	0.8686 0.4752E-03
0.250	0.6500 0.1236E-02	0.8190 0.1571E-02	0.8490 0.7112E-03	0.8634 0.2002E-02	0.8711 0.1605E-02	0.8752 0.6079E-03	0.8812 0.1180E-02	0.8832 0.4015E-03
0.500	0.7934 0.2088E-02	0.8829 0.6541E-03	0.8905 0.1049E-02	0.8949 0.1762E-02	0.8979 0.1166E-02	0.8991 0.1015E-02	0.8996 0.2060E-02	0.8985 0.5521E-03
0.750	0.9044 0.1447E-02	0.9334 0.1674E-03	0.9273 0.1045E-02	0.9229 0.1902E-02	0.9216 0.1295E-02	0.9186 0.7409E-03	0.9174 0.1311E-02	0.9130 0.5004E-03
0.900	0.9864 0.9247E-03	0.9754 0.1282E-02	0.9577 0.1376E-02	0.9472 0.1973E-02	0.9403 0.8830E-03	0.9364 0.1238E-02	0.9300 0.8169E-03	0.9244 0.1113E-02
0.950	1.025 0.2519E-02	0.9997 0.2632E-04	0.9748 0.2633E-02	0.9632 0.1801E-02	0.9537 0.2146E-02	0.9499 0.2391E-02	0.9394 0.9254E-03	0.9324 0.1328E-02
0.975	1.058 0.2693E-03	1.015 0.8745E-03	0.9884 0.2215E-02	0.9768 0.1489E-02	0.9666 0.1098E-02	0.9601 0.4257E-02	0.9461 0.1266E-02	0.9374 0.1666E-02
0.990	1.092 0.1359E-02	1.032 0.7543E-03	1.010 0.1090E-02	0.9909 0.2622E-02	0.9796 0.2078E-02	0.9698 0.4126E-02	0.9552 0.1751E-02	0.9507 0.2343E-02
MEAN OF REGRESSION ON AVERAGES		0.8991 0.3113E-02	0.2048 1.607	-267.8 228.7		0.1164E+05 0.1081E+05	5140. 4708.	
STD DEV OF REGRESSION		0.4999E-02 0.3802E-03	2.809 0.2048	426.1 27.82		0.2111E+05 1325.	9485. 582.0	
REGRESSION ON VARIANCE		0.8567E-01 0.1790	3.798 9.159	-20.98 148.3		180.5 936.7	-439.5 1967.	
ESTIMATOR: $\hat{\sigma}^2$ rho of $N(0,4)$ r.v.s, rho=0.9 using moment estimator								

Figure 5. Sample SIMTBED Super-replication Summary Statistics.

Normal AR(1) data. The next chapter will demonstrate that this good behavior of the robust estimator does not hold for other types of time series, but the point here is that with this combined estimator plot, the behavior is readily apparent, and though all the tabulated data from the entire simulation is available for review, this information is apparent from an immediate glance at this type of plot. Thus, the effort required to perform output analysis from the multi-factor statistical simulation has been significantly reduced through the use of color and graphical displays of the simulation results.

5. Multi-Factor Simulations With SIMTBED.

Chapter II discussed the multi-factor aspects of statistical simulations, and this section discusses how they can be addressed using SIMTBED. There is a direct application of the simulation factor sample size to the SIMTBED package. The SIMTBED subsample size becomes the sample size factor. With SIMTBED, there are five estimators possible, and there are three other factors involved in any common statistical simulation: estimator used, distribution of the samples, and parameters of that distribution. Thus, the estimator parameter of SIMTBED can be used to express any one of these remaining three factors, leaving two factors that will require multiple runs of the SIMTBED simulation. This still represents a great reduction in the amount of separate work required. For example, in the next section we will use four of the five positions of SIMTBED to represent the estimator used, and then SIMTBED will be run for differing combinations of distribution and parameter (e.g., Normal(0,1) $\hat{\rho} = 0.0, 0.9$, and -0.9). When SIMTBED is run on the common personal computer, all one need do is execute SIMTBED in parallel on several available machines, and the multi-factor simulation is completed. Actually, we are using the personal computer itself to apply one factor of the simulation. That was the approach taken for the application presented in the next chapter.

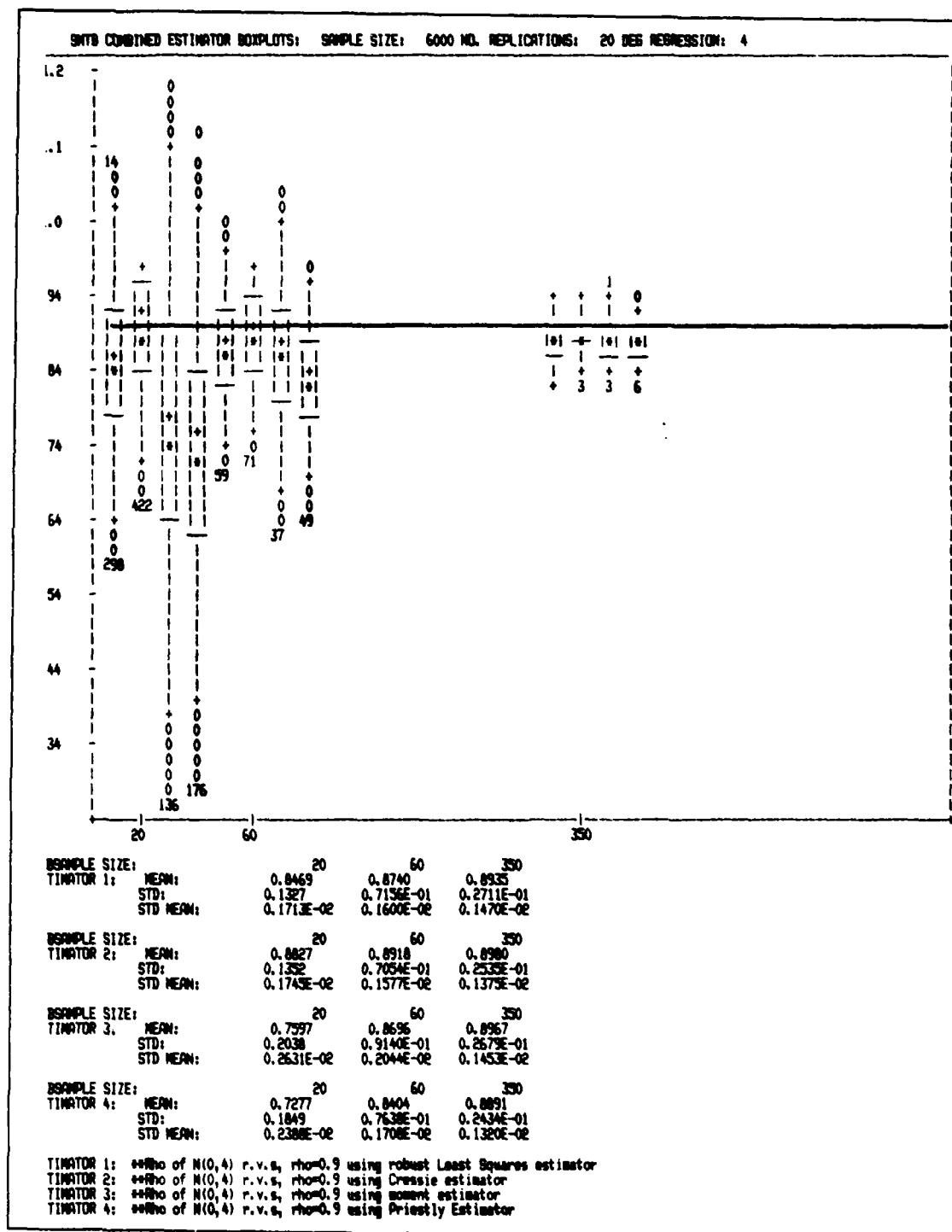


Figure 6. Sample SIMTBED Color Combined Estimator Plots.

IV. ANALYSIS OF LAG-1 SERIAL CORRELATION

The purpose of this chapter is twofold: to provide a demonstration of statistical simulation using SIMTBED, and also to provide some simulation results for some estimators of serial correlation gathered from the literature. Some of these estimators differ from the standard ones in that they have varying degrees of robustness claimed for them, and so we will run simulations to demonstrate this, or the lack of this robustness. By robustness, we mean the ability to produce nearly correct or unbiased estimates of the actual serial correlation when the underlying marginal distribution of the data is no longer the Normal distribution, and the time series are not linear AR(1) processes. With that in mind, the choice of distributions and time series to be used is made. We begin with a description of the estimators of lag-1 serial correlation that are compared, followed by a discussion of the distributions, parameters and processes chosen. The results of these simulations, run with SIMTBED on the PC are then discussed.

A. THE ESTIMATORS.

For this simulation experiment, we have available four estimators of the serial correlation of a random process (random number stream). These are:

- The moment estimator. This is the most widely known and used estimator of serial correlation in a time series, and so is included here. It is a non-parametric estimator.
- The Maximum Likelihood Estimator. Also called the Priestley estimator. Somewhat more involved computationally, and its derivation depends on the explicit assumption that the data comes from a Normal, linear autoregressive (AR(1)) time series.
- The Cressie estimator. Carrying the name of Noel Cressie, this estimator has the potential for robustness because of its choice of the median as the measure of location, rather than the more common mean.
- Robust Least Squares Regression. Also called Iterated Weighted Least Squares (IWLS), this method has appeal in its purported ability to reduce regression errors in successive passes, but the choice of the weighting function must be made, and it can be computationally intense.

Each of these estimators is discussed in greater detail below.

1. The Moment Estimator.

This estimator has a form that is analogous to that for the correlation coefficient for two samples given in any statistics textbook, except that the two samples are

actually the members of only one sample, but offset by one index, i.e., the data is obtained from a time series (discrete parameter stochastic process). This yields, from the Lewis and Orav text on simulation methodology [Ref. 1, p. VIII-57] the following estimator for the lag one serial correlation. The correlation coefficient of lag one is defined as

$$\rho(1) = \frac{\text{Cov}(X_i, X_{i+1})}{\sqrt{\text{Var}(X_i)\text{Var}(X_{i+1})}} = \frac{E[X_i X_{i+1}] - E[X_i]E[X_{i+1}]}{\sqrt{\text{Var}(X_i)\text{Var}(X_{i+1})}}.$$

For stationary time series, the correlation coefficient is independent of time (serial number), and the moment estimator becomes

$$\hat{\rho}_M = \frac{n \sum_{i=1}^{n-1} (X_i - \bar{X})(X_{i+1} - \bar{X})}{(n-1) \sum_{i=1}^n (X_i - \bar{X})^2}. \quad (4.1)$$

The term moment estimator is used for this estimator because the arithmetic mean \bar{x} is used to estimate $E[X]$ and the usual moment estimator is used for $E[X_i X_{i+1}]$. In fact, though, the estimator used in this simulation is the form of equation (4.1) with the $(n-1)$ bias term in the denominator replaced by (n) , which yields the computational form referred to by Lewis and Orav as the Yule-Walker estimator [Ref. 1, p. VIII-56]:

$$\hat{\rho}_M = \frac{\sum_{i=1}^{n-1} (X_i - \bar{X})(X_{i+1} - \bar{X})}{\sum_{i=1}^n (X_i - \bar{X})^2}. \quad (4.2)$$

Again, this estimator is widely used for estimating serial correlation, and as will be seen, has good asymptotic properties as sample size increases (depending on the underlying distribution), but can have significant small-sample bias, especially with time series whose marginal distributions are markedly different from the Normal distribution.

2. The Priestley (conditional M.L.E.) Estimator.

This estimator is put forth as the conditional Maximum Likelihood Estimator (MLE), also called for convenience the Priestley estimator of lag-1 serial correlation [Ref. 8]. It also has good asymptotic properties, as well as the problem of small-sample bias, as the simulations will demonstrate. The estimator is

$$\hat{\rho}_{\text{MLE}} = \frac{\sum_{i=1}^{n-1} (X_i - \hat{\mu})(X_{i+1} - \hat{\mu})}{\sum_{i=1}^{n-1} (X_i - \hat{\mu})^2} . \quad (4.3)$$

where

$$\hat{\mu} = \frac{(A\bar{X}_{(2)} - B\bar{X}_{(1)})}{[(A - B) + (n - 1)\bar{X}_{(1)}(\bar{X}_{(2)} - \bar{X}_{(1)})]} ,$$

and

$$\bar{X}_{(1)} = \begin{array}{l} \text{Average over first } (n - 1) \text{ observations} \\ \text{in the time series of length } n \end{array}$$

$$\bar{X}_{(2)} = \begin{array}{l} \text{Average over last } (n - 1) \text{ observations} \\ \text{in the time series of length } n \end{array}$$

and

$$A = \sum_{i=1}^{n-1} X_i^2 ,$$

and finally,

$$B = \sum_{i=1}^{n-1} X_i X_{i+1} .$$

3. The Cressie Estimator.

This interesting estimator of lag-1 serial correlation has vague sources. It was obtained by personal communication with Cressie by Professor Lewis. The estimator is

$$\hat{\rho}_{CR} = 1 - \frac{1}{2} \left[\frac{\sum_{i=1}^{N-1} (|X_i - X_{i+1}|)^{\frac{1}{2}}}{\sum_{i=1}^{N-1} (|X_i - \tilde{X}|)^{\frac{1}{2}}} \right]^4, \quad (4.4)$$

where \tilde{X} is the median of the sample. One can only comment and speculate on the behavior of this estimator. Lacking analytical results, we resort to statistical simulation to observe its behavior.

B. ROBUST REGRESSION TO ESTIMATE SERIAL CORRELATION.

We start here by presenting the Normal autoregressive lag-1 model (AR(1)), and then show that normal regression yields the usual estimate for ρ discussed in section A.1 above. Then the Iterated Weighted Least Squares (IWLS) procedure is presented, with a short discussion concerning the literature.

In the Normal (Gaussian) AR(1) model, the observations x_{k+1} are determined from the previous x_k , the correlation coefficient ρ , and a random deviation that can be Normal or non-Normal (it is Normal for the Normal model).⁴ Thus,

$$x_{i+1} = \rho x_i + \varepsilon_i. \quad (4.5)$$

This is referred to by Denby and Martin as the "Innovations Outlier Model (IO)" [Ref. 9, p. 140]. They also describe an "Additive Effects Outlier Model (AO)," but that will not be pursued here. The model (4.5) is the approach taken to generate correlated Normal random streams, as will be discussed presently. If one wishes to assume the ε in Equation (4.5) are normally distributed with mean zero, and standard deviation σ , then a zero-intercept regression model can be applied, and shown to yield the moment estimator above. It is when this assumption of normality is not applicable that iterating the least squares procedure with weighting functions can be interesting. Thus, using the matrix notation adopted in the study of linear regression, we can restate the IO model as:

⁴ This model was introduced to me by P.A.W. Lewis, but also appears in [Ref. 9, p. 140].

$$Y = \rho X + \varepsilon \quad (4.6)$$

where Y is the vector of the last $N-1$ members of the random number stream, and X is the vector of the first $N-1$ members. Thus, we are regressing the random stream against itself, offset by one element. Using the matrix solution to the least squares regression procedure:⁵

$$\hat{\rho} = (X^T X)^{-1} X^T Y.$$

This yields, for the IO model above:

$$\hat{\rho} = \frac{\sum_{i=1}^{N-1} X_i X_{i+1}}{\sum_{i=1}^{N-1} X_i^2}$$

This formula actually uses the fact that we know in the simulation that the mean value of the X_i is zero. The sample mean would normally be subtracted from the data, as in Equation 4.2, but this is generally a second order effect. The above formula is actually the starting solution used in the IWLS procedure. From this estimate of ρ , the residuals are computed, from Equation 4.6, by substituting $\hat{\rho}$ for ρ and inverting the (linear) equation. A weighting function is then applied to the residuals, and the weights are multiplied onto the original data points. A data point which gave a small residual will produce a larger weight, and points which produced large residuals will yield smaller weights, even to the point of deletion from the regression for extreme outliers. The scaling constant helps determine these aspects of the weights. The regression is then repeated, yielding a better estimate of ρ , in terms of the residuals. This is briefly discussed by Weisberg [Ref. 10, p. 87], but is presented in more detail by Beaton and Tukey [Ref. 11, pp. 151-152]. These authors refer to this estimation procedure as "w-estimates," being multiple steps of "m-estimates." The common least squares weighting function, the "bi-square" function, given by

⁵ From course notes, OA3103, Prof. Larson, Spring 1987.

$$w(u) = \begin{cases} (1 - u^2)^2 & \text{for } |u| \leq 1 \\ 0 & \text{else} \end{cases} \quad (4.7)$$

is used to determine the weight for the next step of the regression, based on the value of the residuals. The arguments for this function in the IWLS procedure are the residuals calculated from the previous regression step, using the last estimate for ρ . The median, denoted here by S , multiplied by a scaling constant, c (chosen to provide good performance of the IWLS method), is used to scale the residuals. Thus, the argument u for Equation 4.7 becomes

$$u = \frac{r_i}{cS},$$

with r_i denoting the residuals, S the median of the data, and c , the scaling constant, usually taking a value of 4.2 or 6. [Ref. 11, p. 151] In addition, Denby and Martin chose to divide the median by another factor of 0.6745, for reasons not stated. We ran a simulation with and without this factor, and chose the standard approach, without the additional scaling factor.

The procedure just described is also known as robust regression. Indeed, in the International Mathematics and Statistics Library of FORTRAN subroutines (IMSL) implemented on the mainframe computer at the Naval Postgraduate School, there is a subroutine which accomplishes this regression.⁶ Since the source code is available for these routines, it was incorporated into the SIMTBED simulation experiment carried out with this research. The weighting function used there is the bisquare weighting function just described.

Robust regression needs a stopping rule. A comparison of the latest estimated value of ρ with the last estimated value can be used. When there is only slight change the regression can be halted. Additionally, a maximum number of iterations can also be specified.

This robust regression approach to serial correlation is applied in this simulation to both Normal and non-Normal distributions. In their paper on robust estimation of serial correlation, Denby and Martin refer to "M-estimates" and "GM-estimates", or generalized M-estimates, depending on the choice and number of the weighting functions

⁶ All IMSL routines have source code available through the LIBSOURCE utility of the VM/CMS mainframe operating system.

used [Ref. 9, p. 141]. This regression approach, which is applied to their "IO" model, is an "M-estimate", due to the choice of one weighting function, and the use of the "rescending Tukey bisquare influence function". According to Denby and Martin,

As we show subsequently, ϕ_M is highly robust in terms of efficiency for good choices of $\psi(x)$ when model IO holds, but has an asymptotic bias which can be as catastrophic as that of the least squares estimate for Model AO. [Ref. 9, p. 141].

This simulation attempts to compare these biases, restricted to the IO model, in addition to the behavior of the other estimators described. The distributions and random processes used will be discussed below.

C. DISTRIBUTIONS USED.

Two different distributions were used in this simulation for marginal distributions of the processes. The first is the Normal distribution, with mean zero, and variance four, i.e. $N(0,4)$, and the second is the l -Laplace distribution, with parameter l . The processes with these marginal distributions are discussed below.

1. The Normal distribution.

Creating correlated random number streams that are marginally Normally distributed involves a simple application of the IO model described earlier. The only real consideration is the initial value to use, X_0 . This process is referred to as the Normal (or Gaussian) Autoregressive process, AR(1). The IO model is

$$X_{i+1} = \rho X_i + \varepsilon_i,$$

where ε is $\text{Normal}(0, \sigma^2)$. The value of ρ is known. For X_0 , use $\varepsilon_0 / (1 - \rho^2)^{1/2}$. If the variance of the ε random sample is σ^2 , the variance of the X sample, after transformation, will be $\sigma^2 / (1 - \rho^2)$.⁷ So, we can thus construct a correlated stationary normal time series, and then apply all the estimators to it.

2. The l -Laplace Distribution.

A discussion of the l -Laplace family of probability distributions can begin with the widely known Laplace distribution. This distribution is known to be constructed as the difference of two Exponential (λ) random variables, and the standard Laplace random variable has mean zero, and λ equal to one. It is also known that the Exponential distribution is a member of the Gamma family of distributions, with shape parameter equal to one, and scale parameter equal λ (this discussion can be found in almost any

⁷ From P.A.W. Lewis, thesis advisor.

introductory probability text) [Ref. 12, p. 274]. Thus, the standard Laplace distribution (the difference of two standard exponentials) can be obtained as the difference of two Gamma(1,1) random variable streams (the first parameter is taken as the shape, and the second as the scale). DeWald, et al, present the family of distributions defined as *l*-Laplace distributions as being the difference of two Gamma(*l*,1) random variables [Ref. 13, p. 4]. This distribution can take a variety of shapes, as shown in Figure 7. Because of the various shapes possible by the choice of parameter *l* of this distribution, it was selected for the non-Normal simulation in this study.

The *l*-Laplace distribution is symmetric about the origin, and *l* can be chosen to have the shape resemble the Normal distribution (large *l*), or a very heavy-tailed distribution which is very non-Normal in nature (small *l*).

Figure 7 contains examples of empirical histograms for various generated *l*-Laplace samples (Closed forms for the densities are hard to compute). But, these samples are independent, and this simulation is concerned with serial correlation. We need a method to generate *correlated l*-Laplace streams.

Unfortunately, random number streams which are created by the linear first order autoregressive IO model (AR(1)) have what is called a "zero defect," meaning the value zero for the residual can occur with a positive probability. Moreover, if the parameter *l* is small, this effect can become large. Thus, direct application of the method described above for generating correlated Normal random streams (the "linear method") to *l*-Laplace time series can cause severe problems in a simulation such as this, where a lot of processing is done to the random stream. For this reason, DeWald, Lewis and McKenzie introduce the Square Root Beta Laplace transformation and time series, which is non-linear, and does not possess the "zero defect." [Ref. 13, p. 9]

We can take the expression for the Gaussian AR model (Equation 4.5), and treat the correlation parameter (ρ) as a random entity. DeWald, et al, do this, and define the *l*-Beta Laplace First-Order Autoregressive Process, *l*-BELAR(1), as

$$X_l(l) = \sqrt{A_l(l\alpha, l\bar{\alpha})} X_{l-1}(l) + \sqrt{B_l(l\bar{\alpha}, l\alpha)} L_l(l), \quad (4.8)$$

where A_l is an independent, identically distributed (i. i. d.) stream of Beta ($l\alpha, l\bar{\alpha}$) variables, and the B_l 's are also Beta distributed, with parameters given above. $L_l(l)$ is an i. i. d. stream of *l*-Laplace variables with parameter *l*, and $\bar{\alpha}$ equal to $(1-\alpha)$. [Ref. 13, p. 10]. The parameter α is chosen to fix the serial correlation. With this process, any positive correlation can be implemented, with any desired shape of the probability density. As

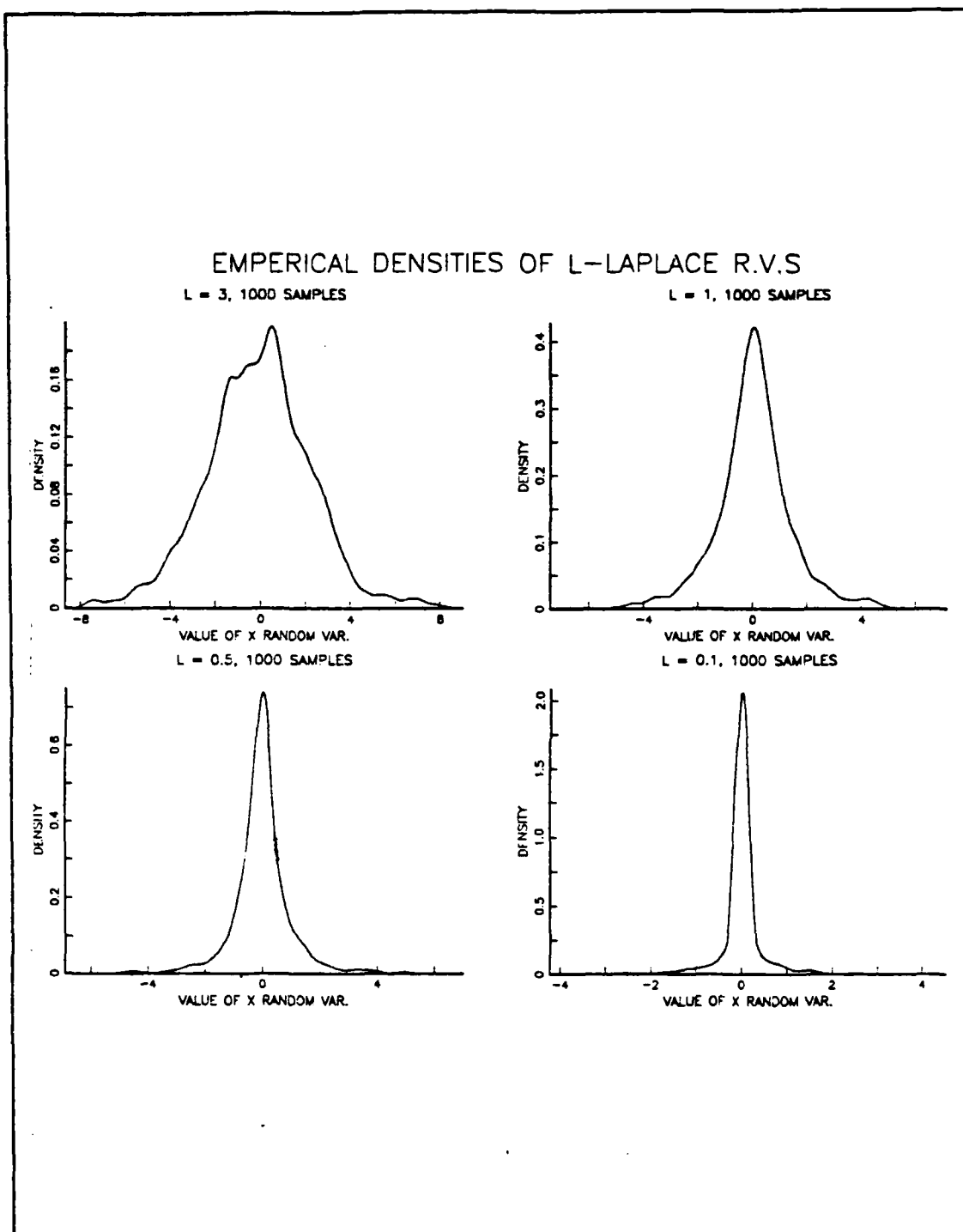


Figure 7. Various Shapes of the l-Laplace distribution

α goes from zero to one, the full range of positive correlations is covered. To see the relation between correlation ρ and α , and l , note that we can interpret this in the IO model discussed above, with the right-most term of Equation 4.8 as the innovation, and the coefficient of $X_{t-1}(l)$ as a randomly distributed correlation coefficient. This approach is taken by DeWald et al, and the correlation coefficient is given in terms of α and l , as the expected value of $\sqrt{A_i(l\alpha, l\bar{\alpha})}$ [Ref. 13, p. 11]:

$$\rho(1) = \frac{\alpha \Gamma(l\alpha + \frac{1}{2}) \Gamma(l+1)}{\Gamma(l + \frac{1}{2}) \Gamma(l\alpha + 1)} \quad (4.9)$$

Thus, this distribution can be used to generate time series with various correlations, and varying degrees of departure from the familiar Normal-shaped distribution, allowing us to investigate the behavior of the statistical estimators of serial correlation under different distributional conditions. Note also that the $L_i(l)$ random stream in Equation 4.8 is an l -Laplace distributed variable, which is computed as the difference of two Gamma random variables.

Figure 8 shows the behavior of several correlated random number streams generated using Equation 4.9. Note that the streams cycle, or consist of long runs of very small values, followed by peak values, and that this correlation can be the same for widely different distributional shapes, given by l (α is then chosen to acquire the desired correlation) [Ref. 13, p. 12].

D. CONDUCT OF THE EXPERIMENT.

It was desired to study the estimators under three conditions of correlation:

- High positive correlation ($\rho = 0.9$).
- Low correlation near independence ($\rho = 0.0$).
- Negative correlation ($\rho = -0.9$).

Due to the complex form of Equation 4.9, it is not possible to get an exact inverse relationship between α and ρ for the non-Normal distribution. Therefore, ρ approximating the above values was used.

We studied five marginal distributional shapes (including the Normal distribution):

- Normally distributed.
- $l = 3$, nearly Normal in shape.
- $l = 1$, departing from Normal behavior.

- $l = .4$, definitely non-Normal.
- $l = .1$, extremely non-Normal.

Further, for the Normal distribution study, we wished to investigate the convergence of the estimators, so a run consisting of up to 23 super-replications of the simulation was conducted to demonstrate this. The speed of Normal random number generators is such that this is possible in a reasonable time. With the Gamma and Beta generators, this type of extended simulation will take an extremely long time, depending on the choice of l and α (a few super-replications can easily take several days, so this type of run could take weeks on a PC).

The sample sizes for the experiment ranged from 20 to 500, with eight being used in all runs (see the results figures in the next chapter). Also, we performed a run with the robust regression estimator using eight sample sizes, the largest sample size being 5000, to observe the bias of this estimator.

Since each run of SIMTBED can accommodate eight sub-sample sizes, these can all be combined in a run. SIMTBED can also take up to five estimators. Four will be used in this experiment, one for each estimator. Thus one run of SIMTBED is required for each distribution and for each correlation under study, giving 15 runs of SIMTBED as a base. Of course, debugging and small-sample checkout of the simulations must be done. This number of runs is a good size project, but not unmanageable. It compares very differently with the example in Chapter 2, without using a simulation package such as SIMTBED. The actual number of runs needed to conduct the experiment is much more than 15 (about 30), since all the programming related factors must be debugged (random number generators, output files, array sizes, etc). The results of the experiment are discussed in the next chapter. The amount of output obtained in an experiment like this is extremely large, even using an analysis package like SIMTBED. Approximately 500 pages of graphs, examples of which follow, were generated by this experiment.

EXAMPLE PLOTS OF CORRELATED L-LAPLACE RANDOM STREAMS

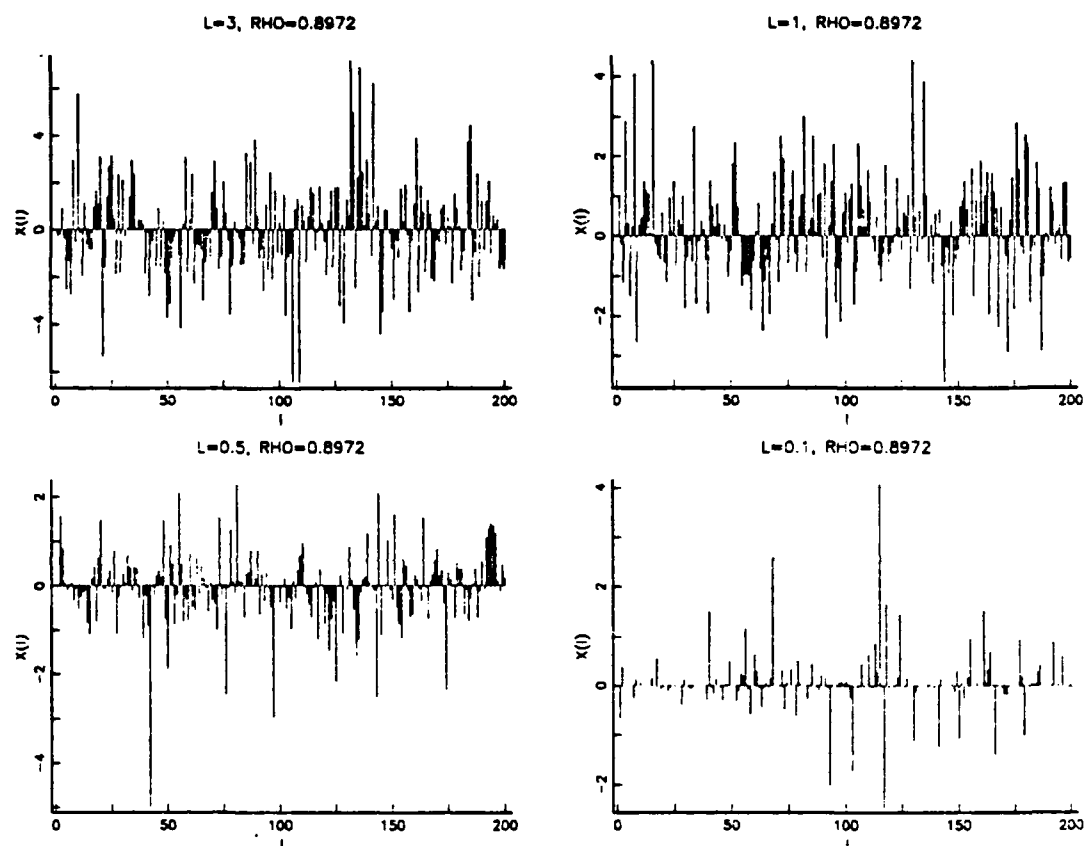


Figure 8. Example Sample Paths for the BELAR(1) Process

V. SIMULATION RESULTS

A. NORMALLY DISTRIBUTED SAMPLES.

Consider first the correlated Normal samples ($\rho = 0.9$). Figure 9 shows the color combined estimator plot for each estimator (for three selected subsample sizes), as is shown in the legend at the bottom of the graph. With this plot added to SIMTBED, immediate comparison of the estimators is possible, and from this graph many things about the behavior of these estimators are evident.

First, all four estimators seem to approach the same value, i.e. the true value $\rho = 0.9$. This is evident from the asymptote lines, which are all plotted at the same location. Further, the tabled data in the plot, as well as the other plots in the following figures, support this observation. So, these estimators can be seen to be asymptotically unbiased, for this sample distribution (Normal).

Next, consider the small-sample distribution of the estimators. It can be seen that the Cressie estimator appears to have the best behavior, in terms of bias at sample sizes 20 through 60, although there are more negative outliers in the plots for the Cressie estimator than for the others. As an example calculation, we can show how many evaluations of each estimator are represented by a particular boxplot. Take sample size 20 for example. The number of evaluations of each of the four estimators represented by the boxplot is:

$$\left(\frac{N \times M}{\text{sub-sample size}} = \frac{6000 \times 20}{20} \right) = 6000 \text{ evaluations}$$

Similar calculations can be done for any sub-sample size in any SIMTBED simulation.

Referring to the tabulated data in Figure 9, we can see the means of all the estimators approaching the known value of 0.9, for all four estimators. The standard deviations can all be seen to decrease as the convergence proceeds with increasing sample size. Note that this is only a brief reproduction of the tabulated data placed in the plots for the individual simulations, shown in the later figures. This plot is designed to accomodate a maximum of five estimators, so brevity is dictated here. Also note that each estimator in the "cluster" of boxplots for each sub-sample size has its description in matching color, but that they are doubly coded by position, so this plot could be used even if color printers were not available.

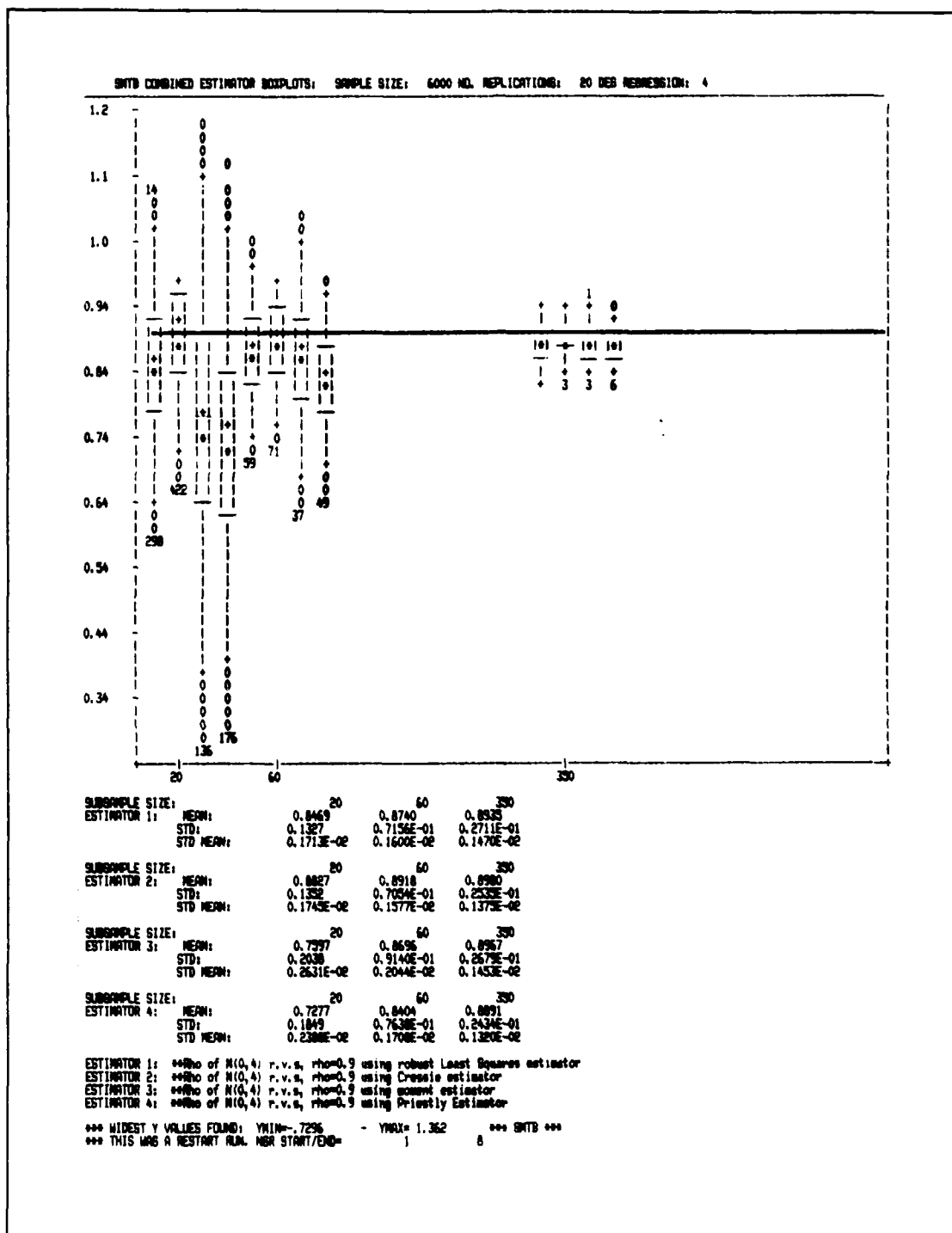


Figure 9. Combined Estimator Plot, Normal, Correlated Samples

Figures 10 and 11 are examples of the individual plots produced as each estimator is processed by SIMTBED. These figures contain the same boxplots that are used to prepare the combined estimator plot of Figure 9. All eight sub-sample size plots are present in Figures 10 and 11. The means of each sub-sample size can be seen to approach the known true correlation of 0.9, and the regression asymptote is listed in the 'mean of regression on averages' listing of the regression equation, which was discussed in Chapter III. Finally, the mean squared error (MSE) is listed in these plots for each sub-sample size. This shows the small-sample bias, and as the sub-sample sizes increase, the MSE approaches the standard deviation of the estimators, which is evidence of decreasing bias from the known value of 0.9. There are plots produced for moment and Priestley estimators which are not included here; they are similar to the those which are included here.

Further insight into the behavior of the estimators is provided from the super-replications summary statistics tables, which are provided in Figures 12, 13, 14, and 15. In the simulation, SIMTBED has duplicated the process which generated the plots of Figures 10 and 11 a total of 23 times, and has 23 values of each statistic presented in the summary table. This was possible because of efficient generation of Normally distributed variables, and this degree of super-replication cannot be efficiently performed for complicated distributions, like the I-BELAR(1) process, due to time requirements, as will be seen later. In these figures, though, we can observe a very good degree of convergence to the known values, for all four estimators, as the sub-sample size increases. The MSE also approaches very closely the standard deviation for all estimators, and the variability of all the statistics in the summary table can be seen to be small. Of interest perhaps is the standard deviation of the fourth moment, the kurtosis, which is the largest of the moment statistics. This is indicative of the higher variability of the higher central moments. We can conclude from this part of the simulation that all four estimators are asymptotically unbiased with respect to sample size. We can further observe that the Cressie estimator appears to be the best behaved in terms of small-sample bias. These results apply only to Normally distributed samples, of course.

The results just discussed apply to only one aspect of the analysis for the Normally distributed samples: those with strong positive correlation. Figures 16 and 17 depict the color combined estimator plots for independent ($\rho = 0.0$) and negatively correlated ($\rho = -0.9$) sample distributions. It is interesting to observe that, in terms of small-sample bias, the uncorrelated Normal samples have the lowest bias, versus the strongly correlated samples. Due to the indicated asymptotic convergence (with respect to

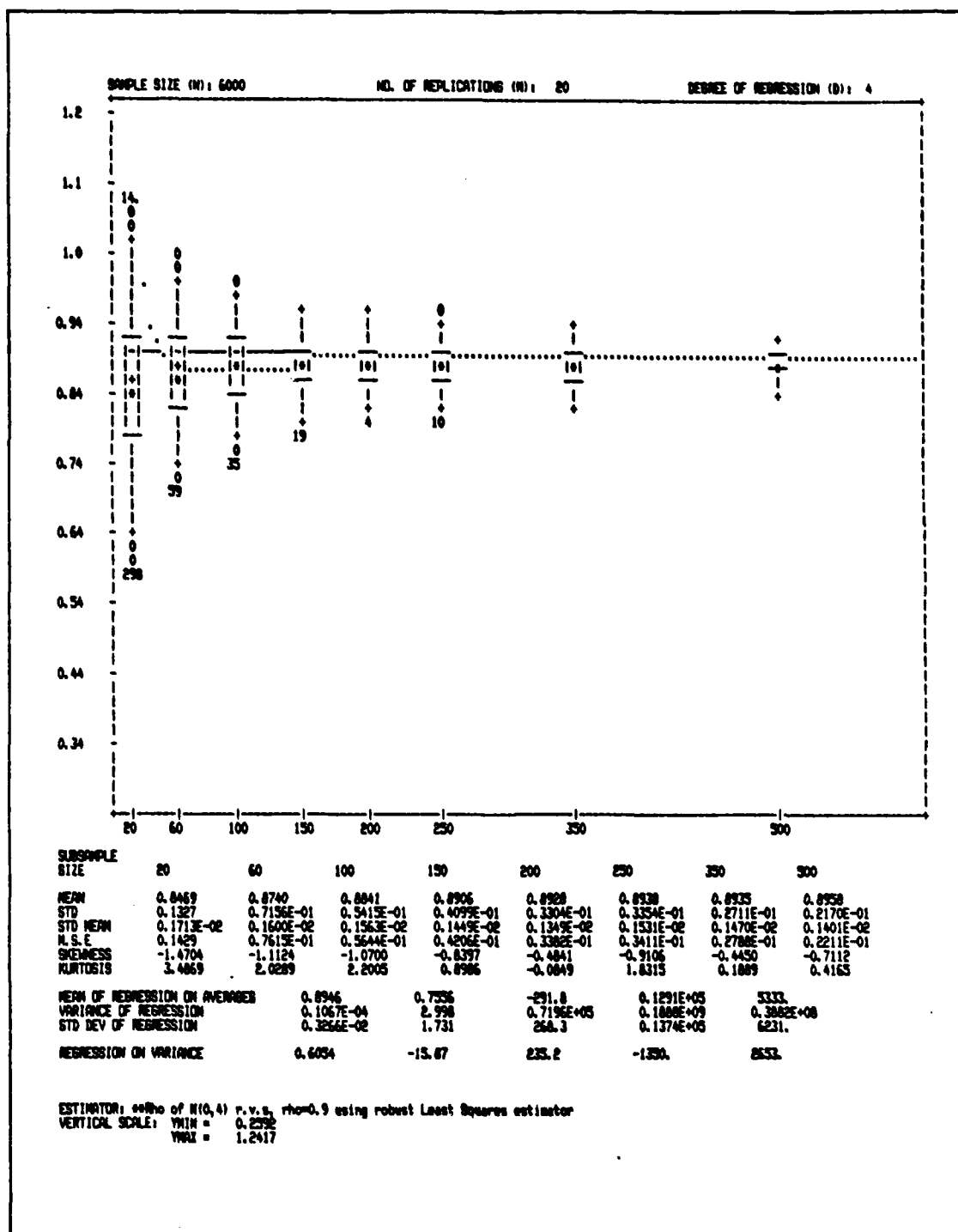


Figure 10. Normal, Correlated Samples. Robust Least Squares Estimator.

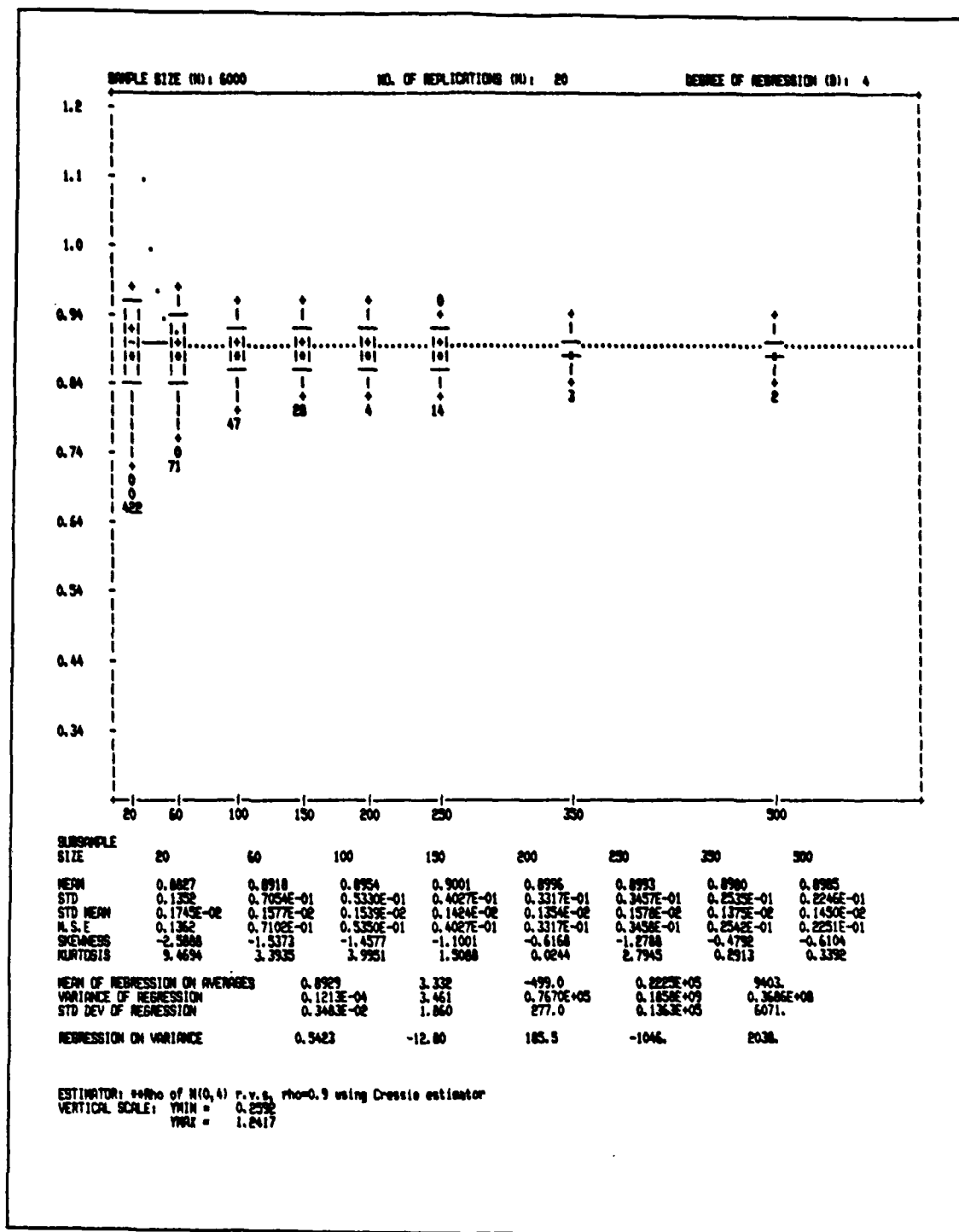


Figure 11. Normal, Correlated Samples. Cressie Estimator.

SUMMARY STATISTICS (MEAN/STD)									23 SUPER-REPLICATIONS									
SUBSAMPLE SIZE	20		60		100		150		200		250		300		350		400	
MEAN	0.8485 0.3737E-03	0.8766 0.2938E-03	0.8847 0.2588E-03	0.8899 0.2648E-03	0.8918 0.2573E-03	0.8932 0.2880E-03	0.8947 0.2478E-03	0.8969 0.2713E-03	0.8989 0.2478E-03	0.8999 0.2713E-03	0.9018 0.2573E-03	0.9032 0.2880E-03	0.9047 0.2478E-03	0.9069 0.2713E-03	0.9089 0.2478E-03	0.9099 0.2713E-03	0.9118 0.2573E-03	0.9132 0.2880E-03
STD	0.1325 0.2858E-03	0.6979E-01 0.8882E-03	0.5130E-01 0.2658E-03	0.4118E-01 0.2578E-03	0.3831E-01 0.2351E-03	0.3122E-01 0.2738E-03	0.2833E-01 0.2863E-03	0.2163E-01 0.8091E-03	0.1918E-01 0.8091E-03	0.1623E-01 0.8091E-03	0.1328E-01 0.8091E-03	0.1033E-01 0.8091E-03	0.0738E-01 0.8091E-03	0.0443E-01 0.8091E-03	0.0148E-01 0.8091E-03	0.0000E-01 0.8091E-03	0.0000E-01 0.8091E-03	0.0000E-01 0.8091E-03
N. S. E	0.1482 0.3584E-03	0.7268E-01 0.3100E-03	0.5373E-01 0.2543E-03	0.4234E-01 0.2323E-03	0.3646E-01 0.2498E-03	0.3807E-01 0.2810E-03	0.2710E-01 0.2447E-03	0.2191E-01 0.2192E-03	0.1672E-01 0.2192E-03	0.1153E-01 0.2192E-03	0.0634E-01 0.2192E-03	0.0115E-01 0.2192E-03	0.0000E-01 0.2192E-03	0.0000E-01 0.2192E-03	0.0000E-01 0.2192E-03	0.0000E-01 0.2192E-03	0.0000E-01 0.2192E-03	0.0000E-01 0.2192E-03
SKEWNESS	-1.563 0.1579E-01	-1.889 0.2793E-01	-0.9856 0.1693E-01	-0.8131 0.2823E-01	-0.7345 0.2806E-01	-0.6898 0.2140E-01	-0.5457 0.3948E-01	-0.5173 0.4518E-01	-0.4689 0.4518E-01	-0.4201 0.4518E-01	-0.3713 0.4518E-01	-0.3225 0.4518E-01	-0.2737 0.4518E-01	-0.2249 0.4518E-01	-0.1761 0.4518E-01	-0.1273 0.4518E-01	-0.0785 0.4518E-01	-0.0297 0.4518E-01
KURTOSIS	4.377 0.1100	2.855 0.2179	1.792 0.1116	1.199 0.9746E-01	0.9843 0.1996	0.6610 0.1384	0.4992 0.1433	0.3921 0.1636	0.3225 0.1636	0.2529 0.1636	0.1833 0.1636	0.1137 0.1636	0.0441 0.1636	0.0000 0.1636	0.0000 0.1636	0.0000 0.1636	0.0000 0.1636	0.0000 0.1636
REL. COR.	0.1886E-03 0.3073E-02	0.9301E-02 0.4579E-02	-0.2308E-02 0.5061E-02	-0.3114E-02 0.7737E-02	-0.6912E-02 0.8181E-02	-0.1159E-01 0.9568E-02	-0.9112E-02 0.1283E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01	-0.3883E-02 0.1643E-01
QUANTILES																		
0.010	0.3847 0.3962E-02	0.6315 0.2206E-02	0.7237 0.1716E-02	0.7681 0.1880E-02	0.7866 0.2059E-02	0.8037 0.1573E-02	0.8214 0.1620E-02	0.8351 0.1592E-02	0.8467 0.1402E-02	0.8574 0.1383E-02	0.8685 0.1364E-02	0.8796 0.1345E-02	0.8907 0.1326E-02	0.9018 0.1307E-02	0.9129 0.1288E-02	0.9240 0.1269E-02	0.9351 0.1250E-02	0.9462 0.1231E-02
0.025	0.5047 0.2300E-02	0.7063 0.1568E-02	0.7622 0.1420E-02	0.7931 0.1007E-02	0.8108 0.1103E-02	0.8224 0.9280E-03	0.8356 0.1143E-02	0.8467 0.1402E-02	0.8574 0.1383E-02	0.8685 0.1364E-02	0.8796 0.1345E-02	0.8907 0.1326E-02	0.9018 0.1307E-02	0.9129 0.1288E-02	0.9240 0.1269E-02	0.9351 0.1250E-02	0.9462 0.1231E-02	0.9573 0.1212E-02
0.050	0.5929 0.1494E-02	0.7461 0.7981E-03	0.7895 0.1202E-02	0.8141 0.7738E-03	0.8271 0.6119E-03	0.8363 0.8721E-03	0.8469 0.7937E-03	0.8574 0.8383E-03	0.8685 0.8091E-03	0.8796 0.7896E-03	0.8907 0.7701E-03	0.9018 0.7506E-03	0.9129 0.7311E-03	0.9240 0.7116E-03	0.9351 0.6921E-03	0.9462 0.6726E-03	0.9573 0.6531E-03	0.9684 0.6336E-03
0.100	0.6808 0.1067E-02	0.7832 0.6924E-03	0.8175 0.8658E-03	0.8358 0.6729E-03	0.8446 0.5690E-03	0.8511 0.6021E-03	0.8592 0.6336E-03	0.8685 0.6091E-03	0.8796 0.5896E-03	0.8907 0.5701E-03	0.9018 0.5506E-03	0.9129 0.5311E-03	0.9240 0.5116E-03	0.9351 0.4921E-03	0.9462 0.4726E-03	0.9573 0.4531E-03	0.9684 0.4336E-03	0.9795 0.4141E-03
0.250	0.7949 0.5102E-03	0.8419 0.4034E-03	0.8569 0.3602E-03	0.8669 0.4186E-03	0.8710 0.3475E-03	0.8747 0.3540E-03	0.8780 0.3988E-03	0.8836 0.4444E-03	0.8907 0.4900E-03	0.9018 0.5311E-03	0.9129 0.5722E-03	0.9240 0.6133E-03	0.9351 0.6544E-03	0.9462 0.6955E-03	0.9573 0.7366E-03	0.9684 0.7777E-03	0.9795 0.8188E-03	0.9906 0.8599E-03
0.500	0.8773 0.2679E-03	0.8888 0.2991E-03	0.8920 0.3570E-03	0.8932 0.2526E-03	0.8960 0.3148E-03	0.8963 0.3232E-03	0.8973 0.2958E-03	0.8986 0.3117E-03	0.9018 0.2722E-03	0.9129 0.2527E-03	0.9240 0.2332E-03	0.9351 0.2137E-03	0.9462 0.1942E-03	0.9573 0.1747E-03	0.9684 0.1552E-03	0.9795 0.1357E-03	0.9906 0.1162E-03	1.0017 0.0967E-03
0.750	0.9324 0.3309E-03	0.9248 0.3544E-03	0.9210 0.2822E-03	0.9190 0.2907E-03	0.9172 0.3548E-03	0.9155 0.3238E-03	0.9137 0.2747E-03	0.9123 0.3036E-03	0.9164 0.2543E-03	0.9275 0.2348E-03	0.9386 0.2153E-03	0.9497 0.1958E-03	0.9608 0.1763E-03	0.9719 0.1568E-03	0.9830 0.1373E-03	0.9941 0.1178E-03	1.0052 0.0983E-03	1.0163 0.0788E-03
0.900	0.9760 0.3695E-03	0.9512 0.4261E-03	0.9484 0.3347E-03	0.9373 0.3227E-03	0.9335 0.3735E-03	0.9307 0.3973E-03	0.9264 0.3454E-03	0.9233 0.3300E-03	0.9294 0.3099E-03	0.9405 0.2904E-03	0.9516 0.2709E-03	0.9627 0.2514E-03	0.9738 0.2319E-03	0.9849 0.2124E-03	0.9960 0.1929E-03	1.0071 0.1734E-03	1.0182 0.1539E-03	1.0293 0.1344E-03
0.950	1.005 0.4111E-03	0.9653 0.4240E-03	0.9539 0.3900E-03	0.9474 0.3688E-03	0.9419 0.3763E-03	0.9386 0.5317E-03	0.9339 0.4118E-03	0.9291 0.4013E-03	0.9352 0.3818E-03	0.9463 0.3623E-03	0.9574 0.3428E-03	0.9685 0.3233E-03	0.9796 0.3038E-03	0.9907 0.2843E-03	1.0018 0.2648E-03	1.0129 0.2453E-03	1.0240 0.2258E-03	1.0351 0.2063E-03
0.975	1.033 0.5911E-03	0.9777 0.5573E-03	0.9635 0.6122E-03	0.9532 0.4930E-03	0.9490 0.4896E-03	0.9451 0.5696E-03	0.9396 0.5684E-03	0.9345 0.5370E-03	0.9406 0.5175E-03	0.9517 0.4980E-03	0.9628 0.4785E-03	0.9739 0.4590E-03	0.9850 0.4395E-03	0.9961 0.4200E-03	1.0072 0.4005E-03	1.0183 0.3810E-03	1.0294 0.3615E-03	1.0405 0.3420E-03
0.990	1.070 0.8586E-03	0.9937 0.8516E-03	0.9750 0.8519E-03	0.9651 0.6636E-03	0.9581 0.6723E-03	0.9531 0.6143E-03	0.9470 0.8324E-03	0.9394 0.6976E-03	0.9455 0.6771E-03	0.9566 0.6576E-03	0.9677 0.6381E-03	0.9788 0.6186E-03	0.9899 0.5991E-03	1.0010 0.5796E-03	1.0121 0.5601E-03	1.0232 0.5406E-03	1.0343 0.5211E-03	1.0454 0.5016E-03
MEAN OF REGRESSION ON AVERAGES	0.9000 0.7927E-03		-1.795 0.3863		40.05 56.07		-1239. 2775.		-511.3 1240.									
STD DEV OF REGRESSION	0.4070E-02 0.1430E-03		2.159 0.8386E-01		327.2 12.70		0.1643E+05 616.7		7372. 271.6									
REGRESSION ON VARIANCE	0.1364 0.7970E-01		4.403 3.592		-66.08 55.39		447.9 343.8		-989.4 719.4									

ESTIMATOR: **rho of N(0,4) r.v.s, rho=0.9 using robust Least Squares estimator

Figure 12. Summary Statistics, Normal Samples. Robust Least Squares.

SUMMARY STATISTICS (MEAN/STD) 23 SUPER-REPLICATIONS								
SUBSAMPLE SIZE	20	60	100	130	200	230	250	300
MEAN	0.7075 0.6741E-03	0.8481 0.3571E-03	0.8706 0.3819E-03	0.8816 0.3483E-03	0.8835 0.2629E-03	0.8889 0.2416E-03	0.8918 0.1963E-03	0.8948 0.2774E-03
STD	0.2337 0.8122E-03	0.8784E-01 0.3766E-03	0.3940E-01 0.3788E-03	0.4478E-01 0.2470E-03	0.3846E-01 0.2368E-03	0.3328E-01 0.2317E-03	0.2779E-01 0.2634E-03	0.2821E-01 0.2206E-03
N. S. E	0.3088 0.9372E-03	0.1080 0.4361E-03	0.6630E-01 0.4717E-03	0.4848E-01 0.3107E-03	0.4110E-01 0.2362E-03	0.2518E-01 0.2414E-03	0.2878E-01 0.2317E-03	0.2894E-01 0.2306E-03
BESMEBS	-1.796 0.2185E-01	-1.444 0.3773E-01	-1.132 0.2434E-01	-0.9486 0.2037E-01	-0.8443 0.4630E-01	-0.7748 0.2838E-01	-0.6725 0.3017E-01	-0.5085 0.3638E-01
RUNTIME	4.735 0.1801	3.360 0.3288	2.039 0.1371	1.364 0.3237E-01	1.235 0.3144	0.9645 0.1135	0.6387 0.2380	0.3037 0.9161E-01
SEL. COV.	0.4448E-02 0.1850E-02	0.1426E-02 0.3949E-02	0.1616E-02 0.5818E-02	0.2187E-02 0.7332E-02	-0.3963E-02 0.9536E-02	-0.1448E-01 0.9541E-02	-0.2790E-01 0.1173E-01	-0.7374E-02 0.1604E-01
QUANTILES								
0.010	-0.1136 0.5099E-02	0.5393 0.2846E-02	0.6828 0.2713E-02	0.7467 0.1498E-02	0.7711 0.2253E-02	0.7885 0.2346E-02	0.8135 0.2014E-02	0.8323 0.1436E-02
0.025	0.5394E-01 0.3823E-02	0.6290 0.1992E-02	0.7247 0.1459E-02	0.7749 0.8285E-03	0.7966 0.1384E-02	0.8117 0.1639E-02	0.8299 0.1141E-02	0.8445 0.1042E-02
0.050	0.2439 0.2422E-02	0.6784 0.1243E-02	0.7583 0.1367E-02	0.7974 0.1023E-02	0.8132 0.8948E-03	0.8269 0.3572E-03	0.8480 0.6320E-03	0.8549 0.7981E-03
0.100	0.3989 0.2008E-02	0.7314 0.9676E-03	0.7918 0.1157E-02	0.8216 0.8118E-03	0.8340 0.6494E-03	0.8445 0.7001E-03	0.8530 0.6210E-03	0.8653 0.5063E-03
0.250	0.6098 0.1098E-02	0.8054 0.6190E-03	0.8391 0.4523E-03	0.8563 0.5684E-03	0.8629 0.3704E-03	0.8697 0.3849E-03	0.8753 0.3633E-03	0.8811 0.3787E-03
0.500	0.7786 0.6972E-03	0.8670 0.4433E-03	0.8814 0.4044E-03	0.8888 0.4276E-03	0.8908 0.3603E-03	0.8930 0.4140E-03	0.8948 0.2471E-03	0.8966 0.4080E-03
0.750	0.8750 0.4881E-03	0.9115 0.3260E-03	0.9135 0.3423E-03	0.9139 0.3181E-03	0.9136 0.3831E-03	0.9129 0.3103E-03	0.9116 0.2522E-03	0.9108 0.3577E-03
0.900	0.9880 0.3734E-03	0.9396 0.2678E-03	0.9358 0.3653E-03	0.9322 0.3178E-03	0.9301 0.4014E-03	0.9281 0.2439E-03	0.9247 0.3197E-03	0.9221 0.3663E-03
0.950	0.9474 0.2724E-03	0.9522 0.2924E-03	0.9461 0.2923E-03	0.9415 0.4187E-03	0.9385 0.3698E-03	0.9399 0.3764E-03	0.9319 0.4278E-03	0.9286 0.4916E-03
0.975	0.9592 0.2574E-03	0.9612 0.3461E-03	0.9539 0.3930E-03	0.9493 0.5072E-03	0.9447 0.4342E-03	0.9421 0.4716E-03	0.9373 0.5166E-03	0.9338 0.6219E-03
0.990	0.9691 0.2916E-03	0.9693 0.3034E-03	0.9616 0.4732E-03	0.9559 0.4803E-03	0.9516 0.3536E-03	0.9490 0.4733E-03	0.9436 0.5153E-03	0.9383 0.6260E-03
MEAN OF REGRESSION ON AVERAGES		0.9004 0.8709E-03	-2.902 0.4460	12.75 68.41	-2092 3449.	-999.9 1531.		
STD DEV OF REGRESSION		0.4623E-02 0.1273E-03	2.536 0.6885E-01	308.4 11.10	0.1933E+05 579.9	8783. 264.2		
REGRESSION ON VARIANCE		0.8652E-01 0.1243	6.971 3.474	-104.3 82.82	766.2 507.8	-1362. 1055.		

ESTIMATOR: $\epsilon \sim N(0,4)$ r.v.s, $\rho=0.9$ using Cressie estimator

Figure 13. Summary Statistics, Normal Samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	60	100	150	200	250	350	500
MEAN	0.7600 0.6871E-03	0.8699 0.3106E-03	0.8854 0.3441E-03	0.8964 0.3933E-03	0.8941 0.2910E-03	0.8965 0.2337E-03	0.8974 0.2850E-03	0.8988 0.2789E-03
STD	0.1996 0.4228E-03	0.9001E-01 0.3313E-03	0.6280E-01 0.2913E-03	0.4613E-01 0.2493E-03	0.3916E-01 0.2713E-03	0.3388E-01 0.2886E-03	0.2730E-01 0.2729E-03	0.2178E-01 0.2103E-03
N.S.E	0.2438 0.6193E-03	0.9493E-01 0.3763E-03	0.6391E-01 0.3196E-03	0.4698E-01 0.2833E-03	0.3963E-01 0.2848E-03	0.3408E-01 0.2376E-03	0.2746E-01 0.2770E-03	0.2186E-01 0.2102E-03
SKEWNESS	-0.9218 0.7841E-02	-0.7961 0.2101E-01	-0.6651 0.1706E-01	-0.4969 0.1604E-01	-0.4635 0.3171E-01	-0.4848 0.2943E-01	-0.3902 0.4017E-01	-0.3111 0.3096E-01
KURTOSIS	1.098 0.3169E-01	1.889 0.9318E-01	1.050 0.7533E-01	0.6774 0.4536E-01	0.6199 0.1293	0.5738 0.6280E-01	0.5366 0.1233	0.5515 0.8273E-01
SEA. COR.	0.8222E-02 0.2836E-02	0.1256E-02 0.3024E-02	0.5333E-02 0.3907E-02	0.1104E-01 0.7012E-02	0.3033E-02 0.8896E-02	-0.1763E-01 0.8031E-02	-0.8087E-01 0.1109E-01	-0.2878E-02 0.1342E-01
QUANTILES								
0.010	0.1624 0.2223E-02	0.6041 0.2602E-02	0.7054 0.2544E-02	0.7645 0.2507E-02	0.7857 0.2013E-02	0.8019 0.2059E-02	0.8221 0.2088E-02	0.8388 0.1313E-02
0.025	0.2810 0.1778E-02	0.6630 0.1958E-02	0.7435 0.1293E-02	0.7896 0.1144E-02	0.8099 0.1186E-02	0.8212 0.1631E-02	0.8383 0.1047E-02	0.8514 0.1077E-02
0.050	0.3800 0.1899E-02	0.7065 0.1218E-02	0.7743 0.1164E-02	0.8107 0.8020E-03	0.8247 0.9220E-03	0.8362 0.1109E-02	0.8498 0.8209E-03	0.8609 0.6623E-03
0.100	0.4882 0.1457E-02	0.7513 0.7031E-03	0.8047 0.8239E-03	0.8322 0.7868E-03	0.8428 0.6183E-03	0.8523 0.7813E-03	0.8616 0.5963E-03	0.8703 0.5294E-03
0.250	0.6500 0.1007E-02	0.8191 0.5297E-03	0.8492 0.4223E-03	0.8646 0.5523E-03	0.8702 0.3573E-03	0.8761 0.3436E-03	0.8803 0.3240E-03	0.8847 0.4219E-03
0.500	0.7928 0.7792E-03	0.8810 0.4412E-03	0.8917 0.4503E-03	0.8964 0.3977E-03	0.8973 0.3869E-03	0.8991 0.2846E-03	0.8992 0.3433E-03	0.9000 0.3773E-03
0.750	0.9053 0.6534E-03	0.9325 0.2772E-03	0.9382 0.4748E-03	0.9236 0.3750E-03	0.9211 0.3584E-03	0.9192 0.2496E-03	0.9162 0.4372E-03	0.9139 0.3562E-03
0.900	0.9840 0.7913E-03	0.9745 0.4338E-03	0.9585 0.5678E-03	0.9475 0.5177E-03	0.9406 0.5084E-03	0.9369 0.3682E-03	0.9300 0.4689E-03	0.9257 0.4222E-03
0.950	1.023 0.6711E-03	0.9984 0.6454E-03	0.9763 0.6317E-03	0.9620 0.6130E-03	0.9533 0.7064E-03	0.9480 0.4783E-03	0.9395 0.5989E-03	0.9321 0.4983E-03
0.975	1.054 0.7002E-03	1.017 0.7544E-03	0.9912 0.6803E-03	0.9758 0.9218E-03	0.9645 0.7890E-03	0.9580 0.8209E-03	0.9463 0.6942E-03	0.9387 0.5863E-03
0.990	1.089 0.1124E-02	1.036 0.8574E-03	1.009 0.8872E-03	0.9904 0.1180E-02	0.9772 0.1176E-02	0.9701 0.1013E-02	0.9575 0.1284E-02	0.9473 0.1003E-02
MEAN OF REGRESSION ON AVERAGES		0.9004 0.8449E-03	-0.7042 0.4236		-96.85 62.88	2082 3105.	677.9 1383.	
STD DEV OF REGRESSION		0.4654E-02 0.1130E-03	2.578 0.6553E-01		398.9 11.09	0.2018E+05 594.0	9077. 273.3	
REGRESSION ON VARIANCE		0.1029 0.1070	4.343 4.793		-42.67 73.48	360.5 455.3	-870.0 953.1	
ESTIMATOR: $\rho = \rho_{0.4}$ of $N(0,1)$ r.v.s, $\rho_{0.9}$ using moment estimator								

Figure 14. Summary Statistics, Normal Samples. Moment Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)								23 SUPER-REPLICATIONS	
	20	60	100	150	200	250	300	300		
MEAN	0.7293 0.4724E-03	0.8403 0.2850E-03	0.8641 0.2848E-03	0.8764 0.3760E-03	0.8816 0.2601E-03	0.8835 0.2363E-03	0.8894 0.1998E-03	0.8932 0.2364E-03		
STD	0.1832 0.3794E-03	0.7673E-01 0.3180E-03	0.5321E-01 0.2934E-03	0.4040E-01 0.2372E-03	0.3442E-01 0.2182E-03	0.3040E-01 0.2966E-03	0.2512E-01 0.2443E-03	0.2028E-01 0.1613E-03		
N.S.E	0.2304 0.3501E-03	0.9720E-01 0.3522E-03	0.6419E-01 0.3606E-03	0.4681E-01 0.3588E-03	0.3907E-01 0.2857E-03	0.3267E-01 0.2210E-03	0.2726E-01 0.2600E-03	0.2141E-01 0.1864E-03		
BIASNESS	-1.044 0.1049E-01	-1.139 0.2239E-01	-1.039 0.2093E-01	-0.8300 0.1978E-01	-0.7417 0.3843E-01	-0.6740 0.2731E-01	-0.6237 0.4198E-01	-0.4724 0.3193E-01		
KURTOSIS	1.543 0.4244E-01	2.201 0.1211	1.842 0.1311	1.636 0.7632E-01	0.8613 0.2004	0.6386 0.5790E-01	0.6491 0.1485	0.2946 0.1000		
SEAL COR.	0.9372E-02 0.1900E-02	0.9046E-02 0.3843E-02	0.3351E-02 0.5853E-02	0.1244E-02 0.8001E-02	-0.4149E-02 0.8783E-02	-0.1313E-01 0.1033E-01	-0.1979E-01 0.1266E-01	-0.9689E-03 0.1618E-01		
QUANTILES										
0.010	0.1621 0.2353E-02	0.3973 0.2081E-02	0.6995 0.2287E-02	0.7370 0.1918E-02	0.7813 0.2053E-02	0.7966 0.2244E-02	0.8160 0.2127E-02	0.8339 0.1411E-02		
0.025	0.2788 0.1552E-02	0.6335 0.1444E-02	0.7357 0.1410E-02	0.7819 0.1182E-02	0.8085 0.1222E-02	0.8135 0.1458E-02	0.8333 0.9667E-03	0.8481 0.9040E-03		
0.050	0.3738 0.1622E-02	0.6953 0.1226E-02	0.7647 0.9900E-03	0.8012 0.8427E-03	0.8184 0.8374E-03	0.8306 0.9789E-03	0.8447 0.6976E-03	0.8570 0.7858E-03		
0.100	0.4807 0.1220E-02	0.7382 0.6890E-03	0.7539 0.7962E-03	0.8224 0.7389E-03	0.8352 0.6563E-03	0.8432 0.7083E-03	0.8561 0.5154E-03	0.8666 0.4250E-03		
0.250	0.6330 0.9068E-03	0.8001 0.5574E-03	0.8354 0.3866E-03	0.8530 0.5704E-03	0.8613 0.4621E-03	0.8675 0.4380E-03	0.8739 0.3223E-03	0.8805 0.3533E-03		
0.500	0.7644 0.6709E-03	0.8546 0.4112E-03	0.8727 0.3324E-03	0.8820 0.4481E-03	0.8856 0.3263E-03	0.8890 0.3506E-03	0.8921 0.2723E-03	0.8946 0.3073E-03		
0.750	0.8990 0.3670E-03	0.8932 0.3021E-03	0.9019 0.3290E-03	0.9054 0.2989E-03	0.9067 0.2533E-03	0.9075 0.2907E-03	0.9078 0.3516E-03	0.9076 0.2507E-03		
0.900	0.9860 0.4399E-03	0.9235 0.3016E-03	0.9236 0.3668E-03	0.9229 0.3538E-03	0.9223 0.2332E-03	0.9217 0.3293E-03	0.9192 0.3634E-03	0.9182 0.3642E-03		
0.950	0.9628 0.5383E-03	0.9378 0.3188E-03	0.9347 0.3796E-03	0.9321 0.3373E-03	0.9302 0.3599E-03	0.9294 0.4063E-03	0.9260 0.2938E-03	0.9241 0.3974E-03		
0.975	0.9942 0.6697E-03	0.9484 0.3677E-03	0.9429 0.3718E-03	0.9394 0.4135E-03	0.9363 0.4239E-03	0.9354 0.5702E-03	0.9314 0.4403E-03	0.9285 0.5457E-03		
0.990	1.033 0.1131E-02	0.9611 0.6073E-03	0.9518 0.4491E-03	0.9474 0.4173E-03	0.9434 0.4999E-03	0.9421 0.6430E-03	0.9375 0.6760E-03	0.9344 0.6133E-03		
MEAN OF REGRESSION ON AVERAGES		0.9009 0.7216E-03	-4.089 0.3700	73.38 54.64	-3531. 2688.	-1612. 1196.				
STD DEV OF REGRESSION		0.4068E-02 0.1257E-03	2.230 0.7074E-01	342.8 11.24	0.1728E+05 582.0	7764. 264.6				
REGRESSION ON VARIANCE		0.1247 0.8608E-01	3.396 3.871	-49.99 59.37	401.4 367.2	-888.4 766.8				
ESTIMATOR: rho of N(0,4) r.v.s, rho=0.9 using Priestly Estimator										
*** WIDEST Y VALUES FOUND: YMIN=-1.130 - YMAX= 1.368 *** ENDS ***										
*** THIS WAS A RESTART RUN. NSR START/END= 16 23										

Figure 15. Summary Statistics, Normal Samples. Priestley Estimator.

sample size) of these samples indicated by the individual plots, the run of 23 super-replications was not repeated. Observe that once familiarity is gained with these plots, a great deal of data can be obtained by the analyst in a very short time. It does, however, take some time to build these simulations.

B. NON-NORMALLY DISTRIBUTED SAMPLES, CORRELATED.

1. Parameter $l = 3$.

The next series of SIMTBED plots describes the behavior of the four estimators for strongly positively correlated l -Laplace variables, with ρ approximately 0.9. Due to the number of runs of this distribution, and the lower efficiency of the random number generators when generating Beta and Gamma distributed variables, only three super-replications were performed.

Figure 18 is a color combined estimator plot from SIMTBED of the four estimators, for sample distributed according to the BELAR(1) process, with l equal three. First, observe that now, all four estimators are not asymptotic to the same value. The sample distribution has begun to depart from Normality, and the estimators are beginning to exhibit corresponding changes. The moment and Priestley estimators appear to be approaching the true value of 0.8972, or very close, while the Cressie estimator has definite bias, and the robust regression estimator is showing slight asymptotic bias.

With respect to small-sample bias, the two estimators that seem to behave well asymptotically also seem to have the worst cases of small-sample bias, as indicated by the boxplots of sub-sample sizes 20 and 60.

Figure 19 is an individual estimator plot for the Cressie estimator. From this plot the asymptote of the regression can be seen to disagree with the true value, and the boxplots demonstrate the small-sample bias for this estimator. A comparison of the standard deviation with the mean squared error also shows the asymptotic bias. The standard deviation of the samples starts at 0.1839, at sub-sample size 20, and steadily decreases to 0.01520 as the sample size increases, but the MSE does not approach the standard deviation, indicating some inherent difference between the true serial correlation and the samples. The MSE decreases from .2322 to .03578 at sub-sample size 150, and then remains relatively constant with respect to sample size. This variability is thus attributed to the bias, not to the random variations of the estimator's calculations on the random samples. Further, from the regression asymptote and its standard deviation, we observe that the regression asymptote of 0.9327 is more than ten standard deviations (0.003479) removed from the true value of .8972; the standard deviation of the regression

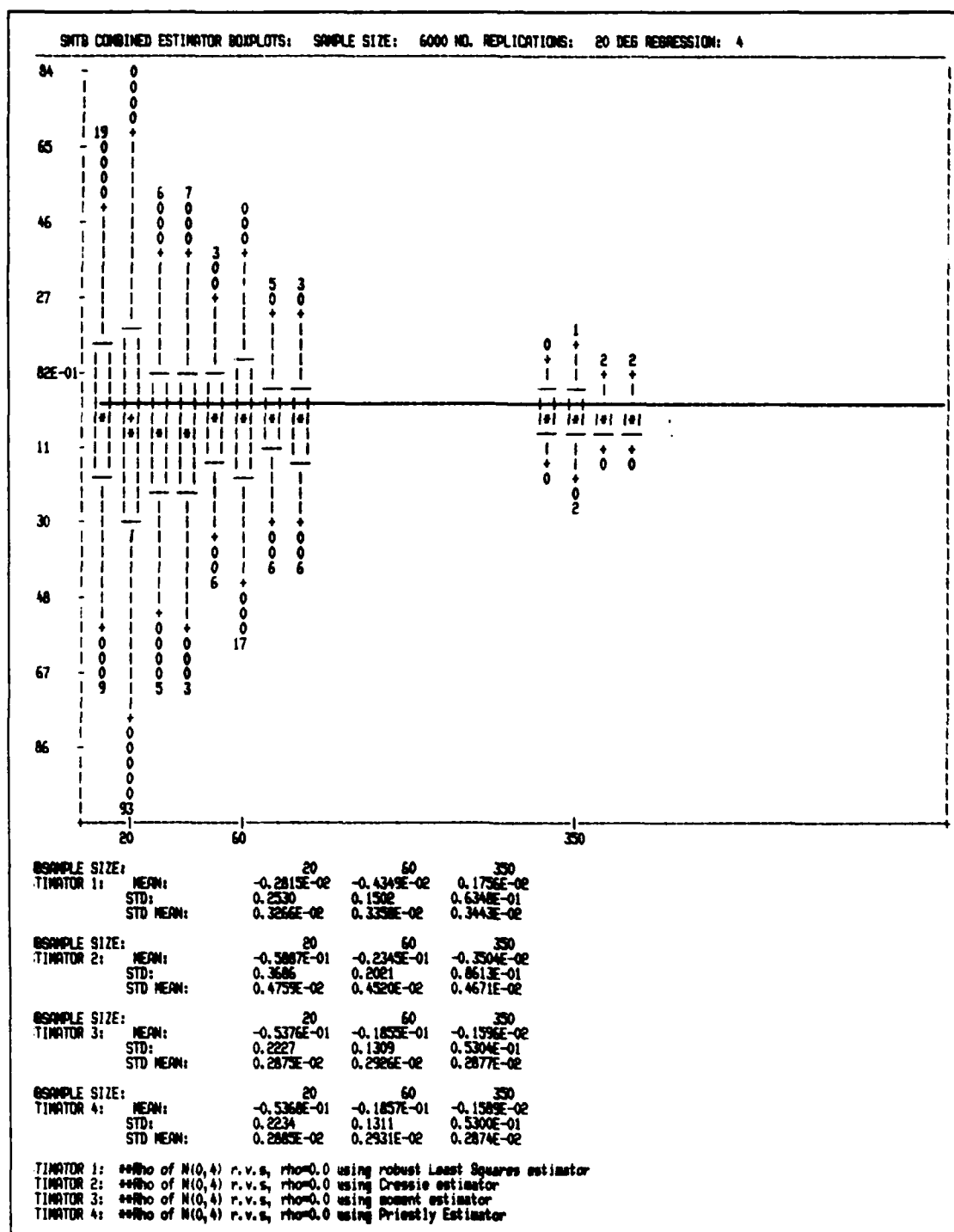


Figure 16. Combined Plot, Normal Samples. Here, Rho = 0.0.

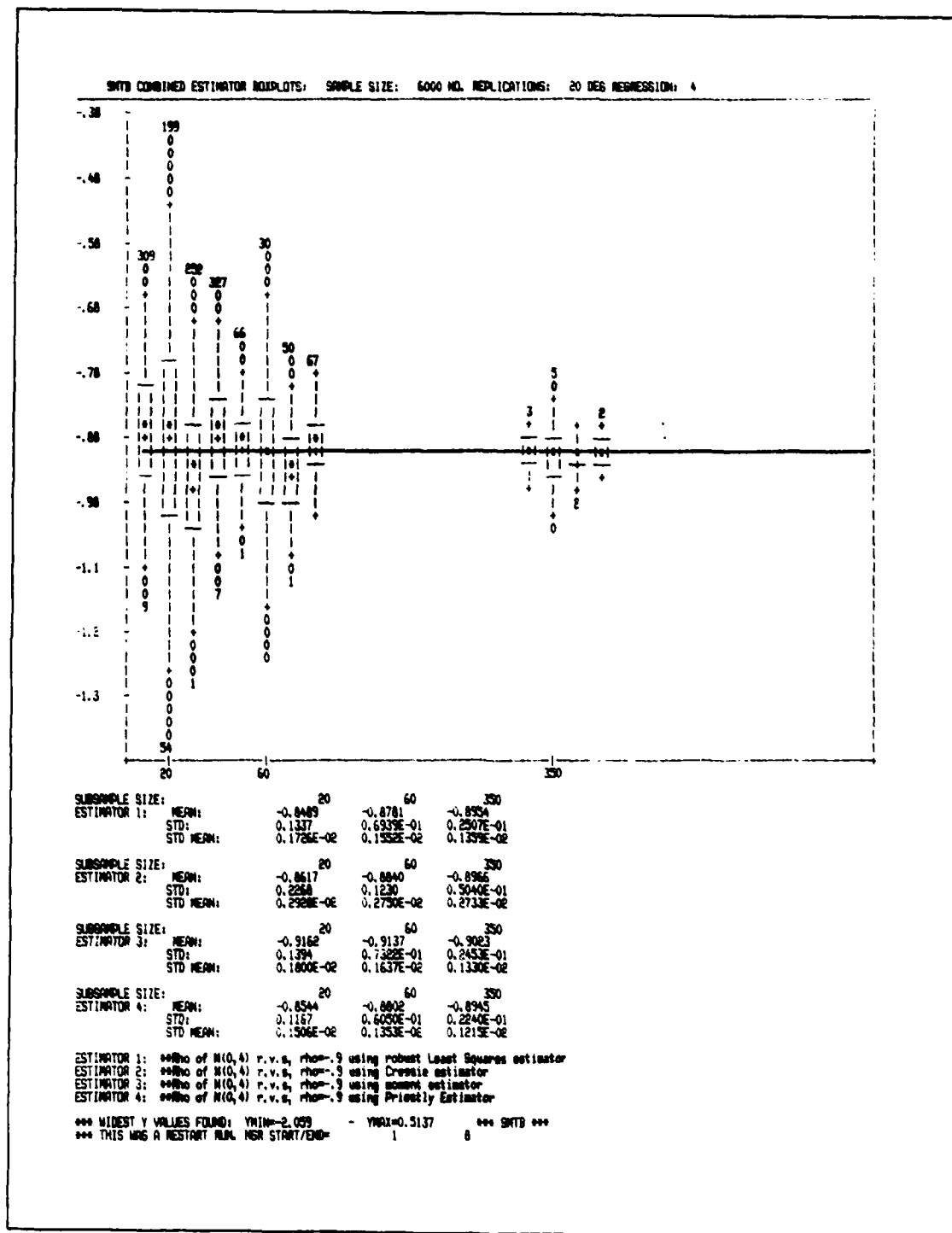
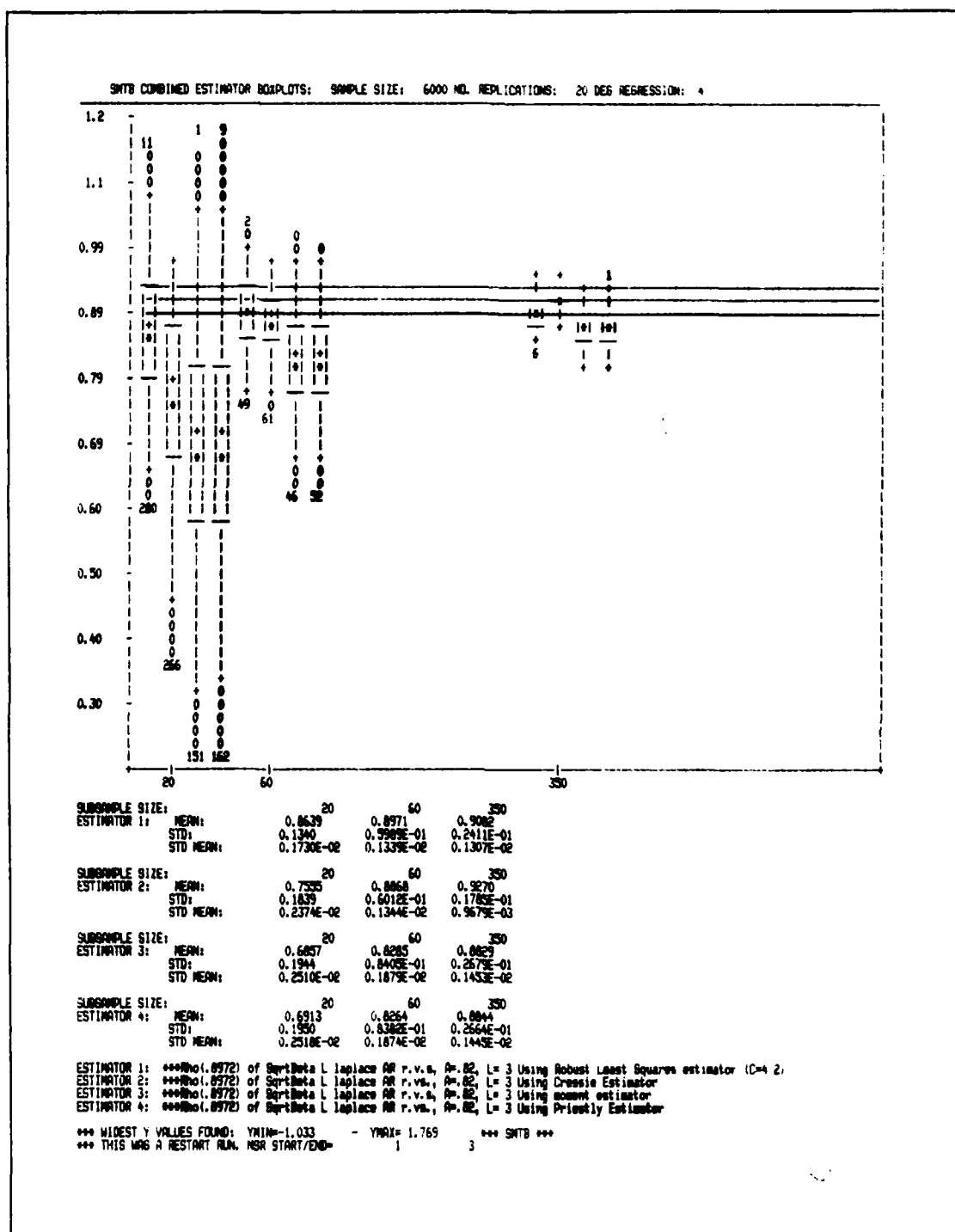


Figure 17. Combined Plot, Normal Samples. Here, $\rho = -0.9$.



coefficients was determined from the 20 replications as part of the generation of this plot.

The summary table for all super-replications (of which there are three) involving the Cressie estimator is shown in Figure 20. With super-replications, the MSE is observed to actually increase, and does not approach the standard deviation at all. The bias of this estimator under conditions of only slightly non-Normal sample seems extreme.

Figures 21 and 22 show the similar behavior for the robust regression estimator. While not as extreme in the case of asymptotic bias (yet) as the Cressie estimator, the robust regression approach seems to approach the wrong value as sample size increases (bias). Again, the MSE decreases, then reaches some (relatively) constant value, reinforcing the case for asymptotic bias. It is noteworthy here to observe that the largest sub-sample size we use is 500, which seems like a reasonable sample size for which to get an acceptable value of serial correlation. Shortly we will observe the behavior of robust regression for even larger sub-sample sizes.

Figures 23 and 24 show the behavior of the moment estimator under these sample distribution conditions ($l = 3$, strong positive correlation). Here we see a large small-sample bias, indicated by the boxplot of sub-sample size 20 falling off from the asymptote line, as well as from the tabulated means, standard deviations, and mean squared errors. With these simulation parameters (overall sample size of 6000, and 20 replications), the regression asymptotic value of 0.8889 for the moment estimator is still accurate to two decimal places (with normal rounding). This, combined with the behavior of the MSE for this estimator, would indicate the estimator is asymptotically unbiased (although it may not approach the correct value as rapidly as would be the case under conditions of Normal samples). From Figure 24, we can see the regression asymptote after three super-replications and observe an even closer value to the true correlation of 0.8972. We conclude the moment estimator is unbiased for this sample distribution.

The simulation behavior of the Maximum Likelihood Estimator (MLE), i.e. the Priestley estimator, is depicted in figures 25 and 26, again, for the parameter l equal to three, and α chosen for strong positive correlation. By a similar analysis, we conclude this estimator is also unbiased, but has a large small-sample bias, just as did the moment estimator.

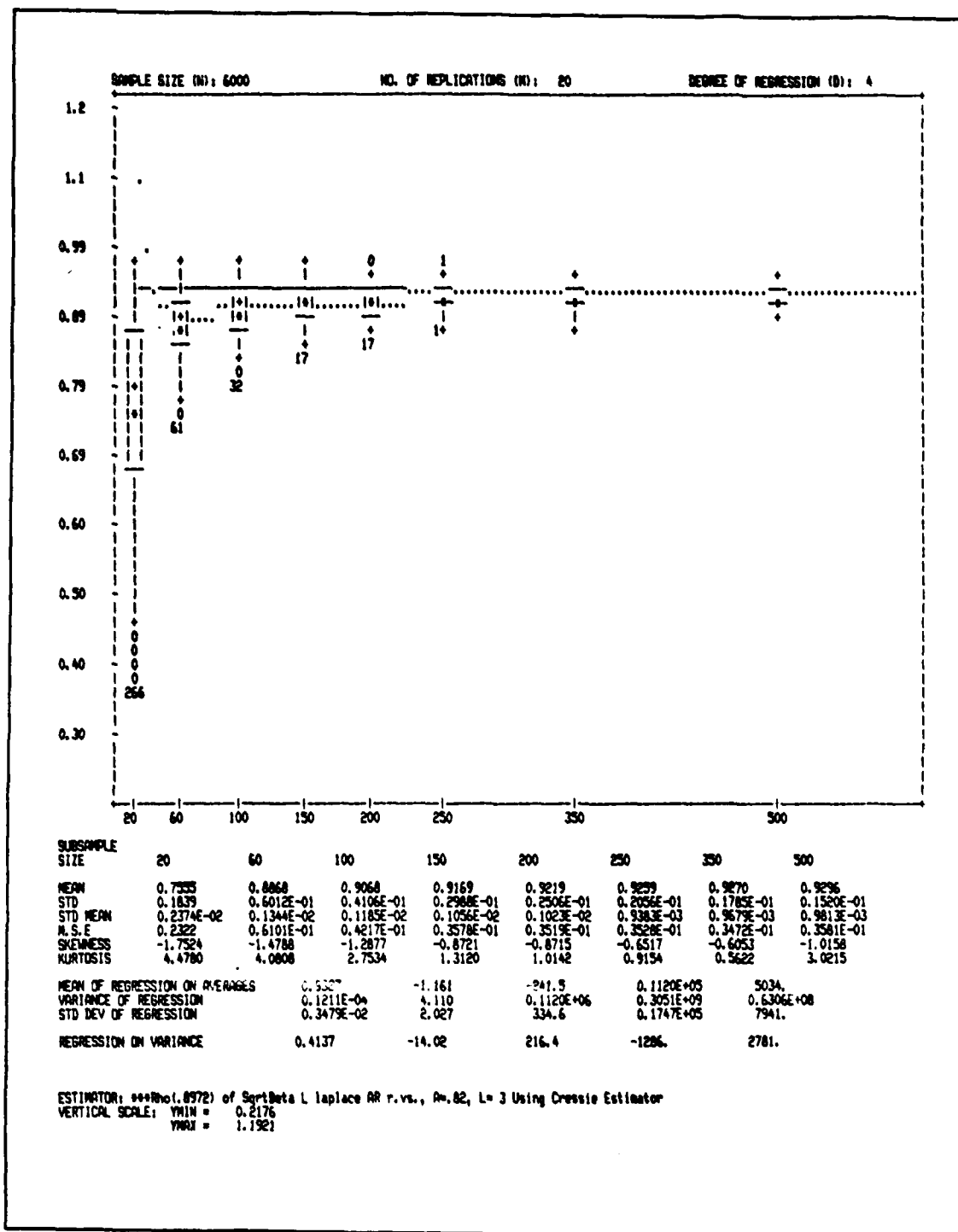


Figure 19. Individual Plot, L-Laplace samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)				3 SUPER-REPLICATIONS			
	20	60	100	150	200	250	350	500
MEAN	0.7384 0.1546E-02	0.8873 0.4051E-03	0.9075 0.5019E-03	0.9163 0.3403E-03	0.9218 0.3023E-03	0.9240 0.9311E-03	0.9266 0.3429E-03	0.9299 0.4870E-03
STD	0.1911 0.3632E-02	0.6070E-01 0.6464E-03	0.4045E-01 0.3250E-03	0.3038E-01 0.7672E-03	0.2503E-01 0.3038E-04	0.2179E-01 0.6200E-03	0.1804E-01 0.3237E-03	0.1477E-01 0.4119E-03
M.S.E	0.2398 0.3818E-02	0.6151E-01 0.6699E-03	0.4173E-01 0.2649E-03	0.3591E-01 0.5178E-03	0.3510E-01 0.2329E-03	0.3461E-01 0.3784E-03	0.3451E-01 0.1343E-03	0.3384E-01 0.2908E-03
SKEWNESS	-1.932 0.1059	-1.616 0.1466	-1.180 0.5408E-01	-0.8993 0.8578E-01	-0.8168 0.6419E-01	-0.7408 0.4266E-01	-0.5863 0.1061E-01	-0.7325 0.1322
KURTOSIS	6.212 0.8923	5.401 1.646	2.357 0.2105	1.287 0.3502	0.9403 0.3114	0.7776 0.6897E-01	0.3729 0.9648E-01	1.387 0.8287
SEMI-COR.	-0.2633E-02 0.9342E-02	0.1576E-01 0.1496E-01	0.2133E-02 0.2121E-01	-0.2496E-01 0.5614E-02	-0.6999E-02 0.1530E-01	-0.3708E-01 0.4370E-01	0.2198E-01 0.6767E-02	0.1213E-01 0.2537E-01
QUANTILES								
0.010	0.7667E-01 0.1814E-01	0.6806 0.3056E-02	0.7779 0.4364E-02	0.8272 0.6567E-02	0.8423 0.5977E-02	0.8558 0.2763E-02	0.8733 0.3516E-02	0.8833 0.2723E-02
0.025	0.2431 0.1059E-01	0.7306 0.5015E-02	0.8118 0.2056E-02	0.8449 0.2862E-02	0.8646 0.1056E-02	0.8732 0.2729E-02	0.8871 0.1648E-02	0.8947 0.1658E-02
0.050	0.3701 0.7259E-02	0.7765 0.1132E-02	0.8304 0.2111E-03	0.8610 0.1791E-02	0.8760 0.1235E-02	0.8836 0.2462E-02	0.8940 0.1220E-02	0.9025 0.1877E-02
0.100	0.5037 0.6074E-02	0.8119 0.1323E-02	0.8538 0.7747E-03	0.8754 0.9083E-03	0.8878 0.1741E-02	0.8943 0.1783E-02	0.9016 0.9868E-03	0.9117 0.1912E-02
0.250	0.6773 0.1981E-03	0.8585 0.6334E-03	0.8868 0.1133E-02	0.8993 0.8607E-03	0.9072 0.1251E-02	0.9118 0.1633E-02	0.9155 0.7947E-03	0.9221 0.3499E-03
0.500	0.8046 0.2448E-03	0.8999 0.7477E-03	0.9148 0.8310E-04	0.9212 0.3722E-03	0.9246 0.1954E-03	0.9269 0.2354E-03	0.9289 0.1967E-03	0.9310 0.7974E-03
0.750	0.8855 0.7422E-03	0.9299 0.1082E-03	0.9362 0.5390E-03	0.9388 0.1171E-03	0.9399 0.3172E-03	0.9394 0.5282E-03	0.9400 0.2182E-03	0.9403 0.2732E-03
0.900	0.9299 0.6629E-03	0.9502 0.7287E-03	0.9517 0.6016E-03	0.9507 0.4503E-03	0.9508 0.6459E-03	0.9499 0.3020E-03	0.9480 0.2753E-03	0.9470 0.1510E-03
0.950	0.9482 0.3642E-03	0.9597 0.6708E-03	0.9597 0.8153E-03	0.9571 0.3398E-03	0.9561 0.2394E-03	0.9550 0.9684E-03	0.9529 0.3480E-03	0.9521 0.3831E-03
0.975	0.9604 0.2178E-03	0.9663 0.4831E-03	0.9632 0.1121E-02	0.9632 0.2711E-03	0.9603 0.2852E-03	0.9590 0.1244E-02	0.9561 0.6296E-03	0.9557 0.5524E-03
0.990	0.9707 0.2251E-03	0.9733 0.9364E-03	0.9717 0.1268E-02	0.9669 0.8901E-03	0.9636 0.6467E-03	0.9639 0.1816E-02	0.9614 0.3041E-03	0.9592 0.2664E-03
MEAN OF REGRESSION ON AVERAGES		0.9354 0.1516E-02	-3.002 0.9717	47.83 155.0	-3081. 7809.	-1280. 3489.		
STD DEV OF REGRESSION		0.2964E-02 0.2850E-03	1.716 0.2114	278.1 40.05	0.1442E+05 2147.	6547. 978.8		
REGRESSION ON VARIANCE		0.1420 0.1400	-1.998 6.245	36.17 94.89	-197.8 581.7	575.5 1197.		

ESTIMATOR: ***rho(.8972) of SqrtBeta L laplace AR r.v.s., A=.82, L= 3 Using Cressie Estimator

Figure 20. Summary Statistics, L-Laplace samples. Cressie Estimator.

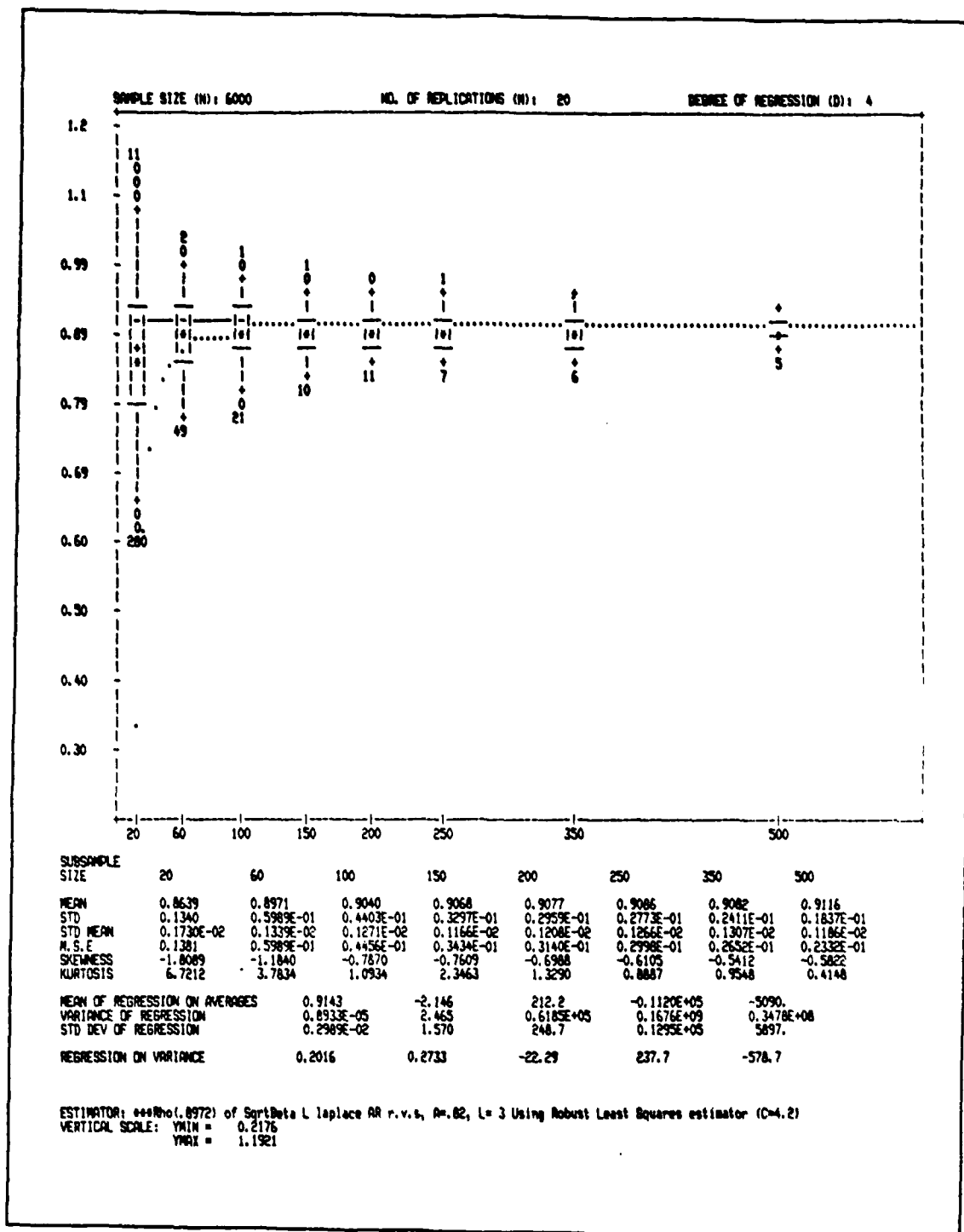


Figure 21. Individual Plot, L-Laplace samples. Robust Least Squares

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	3 SUPER-REPLICATIONS							
	20	60	100	150	200	250	350	500
MEAN	0.8662 0.1292E-02	0.8978 0.3263E-03	0.9033 0.4428E-03	0.9077 0.7323E-03	0.9087 0.1279E-02	0.9093 0.9955E-03	0.9088 0.3678E-03	0.9100 0.8073E-03
STD	0.1305 0.1908E-02	0.6008E-01 0.1090E-02	0.4418E-01 0.1840E-03	0.3387E-01 0.5096E-03	0.2985E-01 0.3070E-03	0.2633E-01 0.7289E-03	0.2280E-01 0.6682E-03	0.1843E-01 0.9430E-03
N. S. E	0.1348 0.2054E-02	0.6009E-01 0.1084E-02	0.4461E-01 0.1353E-03	0.3546E-01 0.6932E-03	0.3190E-01 0.2213E-03	0.2901E-01 0.5359E-03	0.2561E-01 0.4662E-03	0.2244E-01 0.9031E-03
SKEWNESS	-1.718 0.3239E-01	-1.050 0.1236	-0.8212 0.2521E-01	-0.5970 0.8362E-01	-0.6678 0.1812E-01	-0.3663 0.2234E-01	-0.4949 0.2380E-01	-0.6070 0.1141
KURTOSIS	6.041 0.3734	2.497 0.8233	1.424 0.1929	1.106 0.6200	0.9466 0.2129	0.6101 0.1893	0.5894 0.1874	0.8136 0.3188
SER. COR.	-0.6327E-02 0.4302E-02	0.1028E-02 0.1456E-01	-0.1936E-01 0.1129E-01	0.2553E-01 0.2540E-01	-0.4901E-02 0.2317E-01	-0.1304E-01 0.2877E-01	-0.4848E-01 0.7372E-02	-0.8093E-01 0.4174E-01
QUANTILES								
0.010	0.4119 0.1300E-01	0.7087 0.9724E-02	0.7703 0.6874E-02	0.8073 0.2449E-02	0.8260 0.3988E-02	0.8310 0.2569E-02	0.8419 0.6051E-02	0.8542 0.6061E-02
0.025	0.5322 0.4240E-02	0.7521 0.4486E-02	0.8087 0.1326E-02	0.8308 0.6770E-03	0.8420 0.2107E-02	0.8501 0.1706E-02	0.8587 0.1186E-02	0.8686 0.2946E-02
0.050	0.6204 0.5216E-02	0.7875 0.1551E-02	0.8224 0.2062E-02	0.8493 0.2583E-02	0.8545 0.1639E-02	0.8638 0.2088E-02	0.8688 0.6406E-03	0.8761 0.3053E-02
0.100	0.7087 0.4647E-02	0.8220 0.1252E-02	0.8463 0.4762E-03	0.8642 0.1448E-02	0.8702 0.1004E-02	0.8754 0.2981E-02	0.8796 0.1762E-02	0.8863 0.1620E-02
0.250	0.8133 0.2222E-02	0.8633 0.4921E-03	0.8783 0.5644E-03	0.8865 0.5780E-03	0.8912 0.2077E-02	0.8933 0.1129E-02	0.8947 0.1478E-02	0.8991 0.8768E-03
0.500	0.8914 0.1199E-02	0.9071 0.9443E-03	0.9094 0.6388E-03	0.9106 0.1317E-02	0.9114 0.1180E-02	0.9114 0.9327E-03	0.9105 0.9443E-03	0.9110 0.9037E-03
0.750	0.9490 0.8401E-03	0.9386 0.6156E-03	0.9335 0.8418E-03	0.9311 0.1352E-02	0.9289 0.8576E-03	0.9280 0.4546E-03	0.9244 0.4008E-03	0.9230 0.1434E-02
0.900	0.9928 0.4341E-03	0.9641 0.1984E-03	0.9534 0.3329E-03	0.9475 0.1420E-02	0.9434 0.9452E-03	0.9411 0.1002E-02	0.9366 0.5967E-03	0.9321 0.1123E-02
0.950	1.019 0.4790E-04	0.9785 0.1943E-03	0.9647 0.2976E-03	0.9586 0.1317E-02	0.9521 0.1057E-02	0.9489 0.1773E-02	0.9442 0.1021E-02	0.9380 0.1199E-02
0.975	1.047 0.5747E-03	0.9914 0.2168E-03	0.9746 0.1079E-03	0.9659 0.1762E-02	0.9582 0.1351E-02	0.9540 0.1541E-02	0.9493 0.2039E-02	0.9412 0.1816E-02
0.990	1.081 0.2228E-02	1.005 0.4448E-03	0.9852 0.1892E-02	0.9746 0.2358E-02	0.9659 0.2136E-03	0.9594 0.1476E-02	0.9570 0.1839E-02	0.9463 0.1331E-02
MEAN OF REGRESSION ON AVERAGES		0.9080 0.3606E-02	1.238 2.097	-281.7 301.6		0.1293E+03 0.1440E+05	3584. 6301.	
STD DEV OF REGRESSION		0.3379E-02 0.2371E-03	1.775 0.1592	271.0 25.08		0.1374E+03 1207.	6189. 527.7	
REGRESSION ON VARIANCE		0.3316 0.1480	-6.580 5.923	90.36 82.03		-476.7 464.5	916.9 908.5	
ESTIMATOR: ***rho(.8972) of SqrdBeta L Laplace AR r.v.s, Ar.82, L= 3 Using Robust Least Squares estimator (C=4.2)								

Figure 22. Summary Statistics, L-Laplace samples. Robust Least Squares

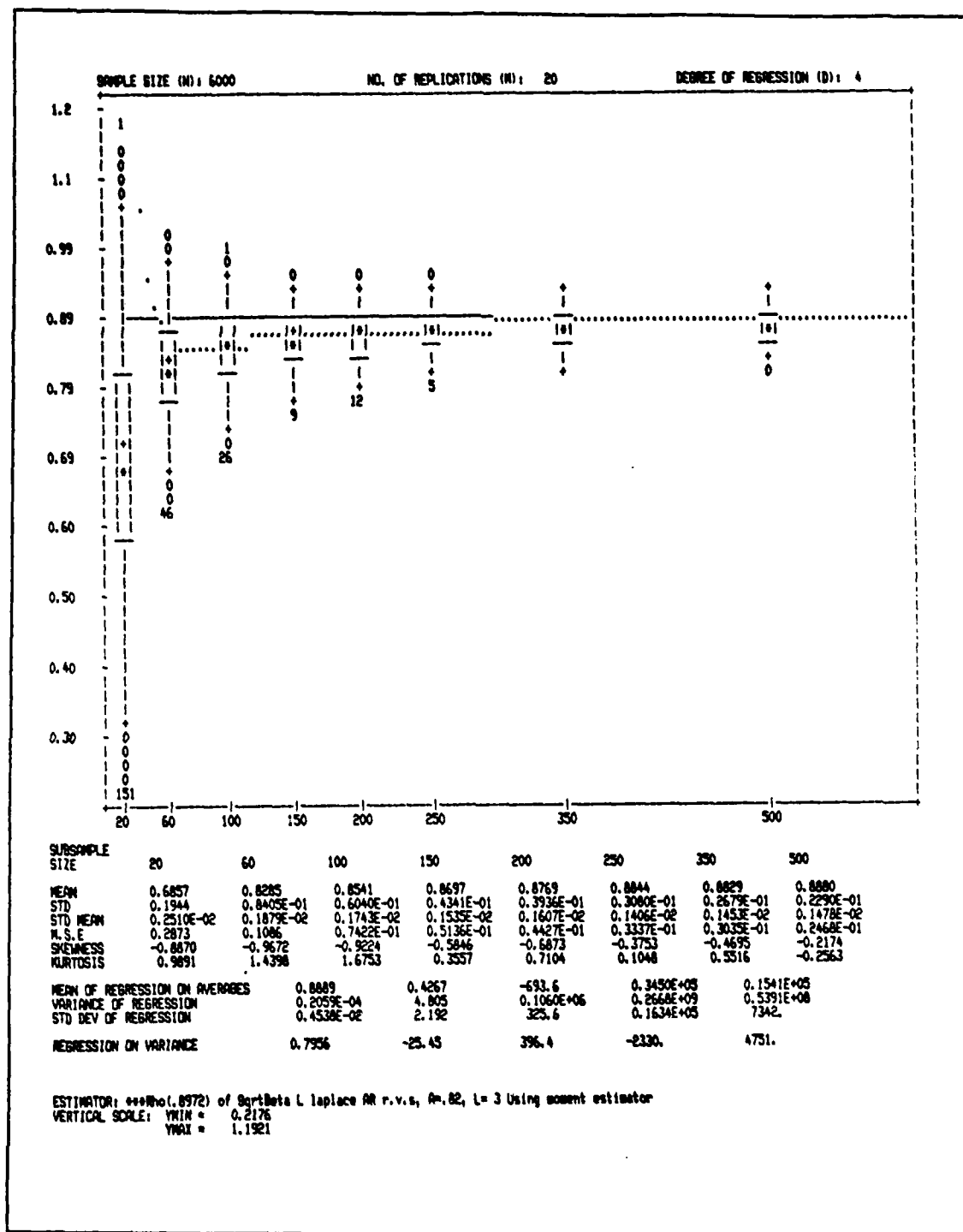


Figure 23. Individual Plot, L-Laplace samples. Moment Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	60	100	150	200	250	300	300
MEAN	0.6874 0.1849E-02	0.8299 0.7716E-03	0.8561 0.1025E-02	0.8690 0.3937E-03	0.8765 0.4811E-03	0.8827 0.9492E-03	0.8844 0.7484E-03	0.8891 0.1160E-02
STD	0.1940 0.1179E-02	0.8322E-01 0.5424E-03	0.9983E-01 0.1273E-02	0.4518E-01 0.1039E-02	0.3873E-01 0.3381E-03	0.3148E-01 0.7016E-03	0.2704E-01 0.5156E-03	0.2239E-01 0.5928E-03
N. S. E	0.2857 0.2133E-02	0.1070 0.7893E-03	0.7850E-01 0.1286E-02	0.5328E-01 0.1064E-02	0.4394E-01 0.3695E-03	0.3409E-01 0.7362E-03	0.2992E-01 0.5400E-03	0.2404E-01 0.9654E-03
SKEWNESS	-0.9477 0.3128E-01	-0.9344 0.2293E-01	-0.9904 0.6983E-01	-0.7313 0.9484E-01	-0.8229 0.8293E-01	-0.4499 0.3941E-01	-0.4607 0.1003	-0.5149 0.1740
KURTOSIS	1.232 0.1278	1.940 0.5849E-01	2.065 0.3005	1.181 0.4990	1.360 0.5141	0.2761 0.9601E-01	0.3169 0.2207	1.052 0.7837
SEMI-COR.	0.3842E-03 0.1160E-02	0.2802E-02 0.3988E-02	0.1378E-01 0.1311E-01	-0.1813E-01 0.2933E-01	-0.3241E-02 0.2326E-01	-0.1749E-01 0.2286E-01	0.3371E-02 0.7194E-01	-0.3030E-01 0.4585E-01
QUANTILES								
0.010	0.1065 0.3629E-02	0.5763 0.2412E-02	0.6799 0.8594E-02	0.7426 0.2236E-02	0.7585 0.3032E-02	0.7970 0.5129E-02	0.8096 0.7283E-02	0.8261 0.1931E-02
0.025	0.2144 0.2442E-02	0.6343 0.2174E-02	0.7165 0.3386E-02	0.7681 0.5216E-02	0.7862 0.3658E-02	0.8136 0.3298E-02	0.8274 0.1880E-02	0.8434 0.2983E-02
0.050	0.3181 0.5277E-02	0.6765 0.2757E-02	0.7466 0.2981E-02	0.7880 0.2270E-02	0.8061 0.2373E-02	0.8266 0.2771E-02	0.8371 0.3376E-03	0.8507 0.2608E-02
0.100	0.4234 0.4652E-02	0.7183 0.3028E-02	0.7781 0.2193E-02	0.8082 0.2071E-02	0.8264 0.1909E-02	0.8411 0.1364E-02	0.8475 0.1144E-02	0.8600 0.2905E-02
0.250	0.5821 0.2262E-02	0.7841 0.9969E-03	0.8232 0.9590E-03	0.8414 0.1653E-02	0.8539 0.5614E-03	0.8639 0.1353E-02	0.8683 0.6843E-03	0.8738 0.1711E-02
0.500	0.7213 0.1430E-02	0.8425 0.9129E-03	0.8636 0.1127E-02	0.8744 0.1168E-02	0.8811 0.4967E-03	0.8845 0.1451E-02	0.8863 0.1021E-02	0.8900 0.1244E-02
0.750	0.8248 0.1548E-02	0.8900 0.1043E-02	0.8990 0.1829E-02	0.9020 0.7345E-03	0.9036 0.5512E-03	0.9051 0.2939E-03	0.9039 0.1049E-02	0.9035 0.5232E-03
0.900	0.9013 0.4793E-03	0.9236 0.1075E-02	0.9240 0.1375E-02	0.9216 0.7097E-03	0.9207 0.1056E-02	0.9216 0.1085E-02	0.9173 0.1167E-02	0.9169 0.7682E-03
0.950	0.9413 0.1731E-02	0.9401 0.8416E-03	0.9362 0.7853E-03	0.9330 0.1567E-02	0.9310 0.1773E-02	0.9302 0.1723E-02	0.9234 0.8162E-03	0.9239 0.1458E-02
0.975	0.9766 0.2496E-02	0.9550 0.1713E-02	0.9472 0.8573E-03	0.9406 0.1154E-02	0.9397 0.1459E-02	0.9364 0.9242E-03	0.9305 0.1200E-02	0.9287 0.4263E-03
0.990	1.015 0.2242E-02	0.9685 0.2126E-02	0.9568 0.1795E-02	0.9530 0.1786E-02	0.9508 0.1856E-02	0.9468 0.4480E-02	0.9398 0.3142E-02	0.9355 0.7145E-03
MEAN OF REGRESSION ON AVERAGES		0.8963 0.4464E-02	-3.500 2.242	-109.3 324.8	6293. 0.1558E+05	3009. 6842.		
STD DEV OF REGRESSION		0.4508E-02 0.2209E-03	2.362 0.1113	366.2 21.49	0.1876E+05 1235.	8496. 581.5		
REGRESSION ON VARIANCE		0.5691 0.1381	-16.17 6.730	269.5 110.7	-1630. 719.2	3421. 1548.		

ESTIMATOR: ***rho(.8972) of SqriBeta L laplace RR r.v.s, $\mu=.82$, $L=3$ Using moment estimator

Figure 24. Summary Statistics, L-Laplace samples. Moment Estimator.

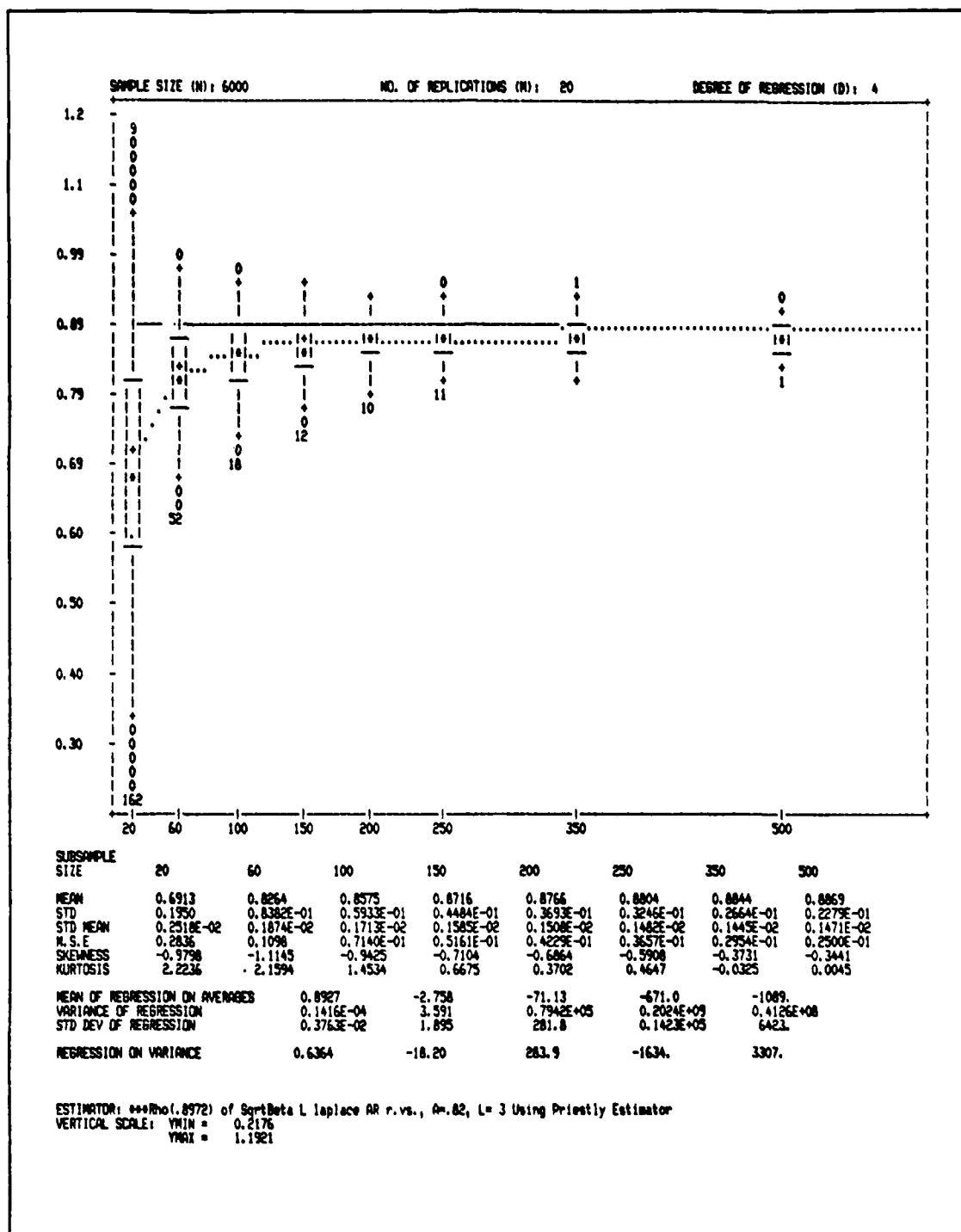


Figure 25. Individual Plot, L-Laplace samples. Priestley Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)				3 SUPER-REPLICATIONS			
	20	60	100	150	200	250	300	300
MEAN	0.6917 0.2270E-03	0.8270 0.3948E-03	0.8566 0.4744E-03	0.8719 0.5483E-03	0.8770 0.5963E-03	0.8816 0.6299E-03	0.8867 0.1173E-02	0.8879 0.5948E-03
STD	0.1950 0.6702E-04	0.8168E-01 0.1534E-02	0.5835E-01 0.8978E-03	0.4501E-01 0.1589E-03	0.3768E-01 0.3879E-03	0.3322E-01 0.4926E-03	0.2639E-01 0.3214E-03	0.2262E-01 0.9844E-04
M.S.E	0.2833 0.1870E-03	0.1077 0.1417E-02	0.7108E-01 0.3181E-03	0.5166E-01 0.2800E-03	0.4273E-01 0.2881E-03	0.3670E-01 0.5030E-03	0.2844E-01 0.6773E-03	0.2447E-01 0.3157E-03
SKEWNESS	-0.9581 0.1387E-01	-0.9541 0.8558E-01	-0.9443 0.2442E-01	-0.7927 0.6570E-01	-0.6319 0.5493E-01	-0.6095 0.4084E-01	-0.4438 0.6199E-01	-0.3528 0.9349E-02
KURTOSIS	1.823 0.2022	1.388 0.3995	1.608 0.2350	0.8451 0.2434	0.4770 0.8291E-01	0.4435 0.2125E-01	0.9893E-01 0.1717	0.1564E-01 0.8717E-01
SER. COR.	-0.6990E-02 0.3530E-02	0.6734E-02 0.1441E-01	0.2050E-02 0.1161E-01	-0.7611E-02 0.1191E-01	0.5194E-02 0.1459E-01	0.1208E-01 0.5170E-01	0.1226E-01 0.3999E-01	0.6532E-01 0.1630E-01
QUANTILES								
0.010	0.1042 0.7244E-02	0.5754 0.8325E-02	0.6838 0.6605E-02	0.7340 0.3983E-02	0.7671 0.5578E-02	0.7831 0.1219E-02	0.8174 0.2599E-02	0.8289 0.9947E-03
0.025	0.2200 0.7299E-02	0.6277 0.3223E-02	0.7208 0.2237E-02	0.7700 0.2273E-02	0.7939 0.2057E-02	0.8063 0.4058E-02	0.8277 0.2317E-02	0.8397 0.1557E-02
0.050	0.3225 0.1957E-02	0.6749 0.3507E-02	0.7492 0.1186E-02	0.7910 0.1672E-02	0.8099 0.1373E-02	0.8211 0.1997E-02	0.8390 0.3010E-02	0.8462 0.1933E-02
0.100	0.4308 0.1486E-02	0.7189 0.2779E-02	0.7768 0.8848E-03	0.8106 0.1743E-02	0.8251 0.1084E-02	0.8369 0.1081E-02	0.8487 0.1735E-02	0.8586 0.9670E-03
0.250	0.5886 0.2043E-02	0.7824 0.3129E-03	0.8235 0.3865E-03	0.8462 0.1929E-02	0.8542 0.1346E-02	0.8613 0.3063E-03	0.8704 0.1149E-02	0.8733 0.7283E-03
0.500	0.7239 0.2230E-02	0.8400 0.8701E-03	0.8662 0.1235E-02	0.8779 0.6014E-03	0.8811 0.3518E-03	0.8854 0.7980E-03	0.8881 0.1525E-02	0.8889 0.2623E-03
0.750	0.8280 0.2780E-03	0.8858 0.8113E-03	0.8989 0.1135E-02	0.9051 0.5992E-03	0.9040 0.6763E-03	0.9035 0.1474E-02	0.9060 0.9489E-03	0.9041 0.8847E-03
0.900	0.9031 0.4087E-03	0.9186 0.1109E-02	0.9228 0.1678E-02	0.9240 0.2218E-03	0.9216 0.2337E-02	0.9202 0.5077E-03	0.9185 0.1148E-02	0.9152 0.8643E-03
0.950	0.9464 0.1333E-02	0.9359 0.6841E-03	0.9356 0.2097E-02	0.9335 0.8015E-03	0.9328 0.1769E-02	0.9301 0.5609E-03	0.9248 0.1190E-02	0.9233 0.3677E-03
0.975	0.9852 0.1892E-02	0.9490 0.3994E-03	0.9442 0.1547E-02	0.9414 0.1164E-02	0.9401 0.7899E-03	0.9369 0.1525E-02	0.9318 0.1145E-02	0.9269 0.1114E-02
0.990	1.030 0.2861E-02	0.9636 0.1536E-02	0.9548 0.1812E-02	0.9504 0.1054E-02	0.9470 0.2529E-02	0.9439 0.1290E-02	0.9402 0.1289E-02	0.9355 0.2436E-02
MEAN OF REGRESSION ON AVERAGES		0.8936 0.1545E-02	-2.205 0.6609		-226.6 106.2	8801. 5636.	3438. 2592.	
STD DEV OF REGRESSION		0.4253E-02 0.3847E-03	2.225 0.1972		329.9 25.74	0.1633E+05 1065.	7285. 431.5	
REGRESSION ON VARIANCE		0.3184 0.2538	-4.712 11.89		92.89 188.6	-358.6 1197.	1238. 2546.	

ESTIMATOR: ***rho(.8972) of SqrtBeta L laplace AR v.s., $\rho=.82$, $L=3$ Using Priestley Estimator

Figure 26. Summary Statistics, L-Laplace samples. Priestley Estimator.

2. Parameter $l = 1$.

This set of parameters is the first encounter with the fact that the random generators, for large samples, will generate one or more numbers which are smaller than (closer to zero than) the smallest number representable in the Ryan-McFarland Fortran compiler for micros. The number then becomes a NAN (Not A Number) and propagates through the computations as ???????. Figure 27 is a color combined SIMTBED plot, and it shows the undefined results which ripple through all calculations when an invalid number is returned by the random number generator. This is believed to result from an underflow error because the parameters of the underlying probability distribution that we are asking the FORTRAN subroutines to generate are very small. This results in random numbers generated which are very close to, but not equal to zero. The random number generators must perform transformations involving logarithms and square roots to generate these Gamma and Beta distributions, and when the parameters become very small, and the generators are operated very frequently, as they are with SIMTBED and these simulations, it happens that an underflow occurs and an invalid result is returned. This ripples through every mathematical operation and appears in the results, an example of which is Figure 27. In this particular example, the parameter l is set to one, or very nearly one (0.95 was used to try and circumvent the problem in this particular example). Since there are two Beta random streams required to generate the l -BELAR(1) process, with parameters $(\alpha l, (1-\alpha)l)$, it is true that when l is one, and we want either a high or low correlation, then either α or $(1-\alpha)$ will be small. This causes the Beta generator (which generates Beta numbers as the ratio of Gammas) to underflow. This is a rare event, but the number of operations of a random number generator by SIMTBED is extremely large (they are at the heart of the statistical simulation process), and only one occurrence is needed to invalidate the entire simulation run. For these reasons, we were not able to obtain acceptable results for this parameter of the BELAR(1) process. Every available random number generator was tried, and all of them have problems generating Gamma random numbers with very small parameters. Therefore, we continue with the next case.

3. Parameter $l = 0.4$.

This case did not exhibit the type of random number generator problem described above. Figure 28 is the color combined estimator plot for the case of $l = 0.4$, with strongly correlated BELAR(1) samples. From this plot it is immediately obvious that there is a difference in the asymptotic behavior of the estimators. It can be seen that the robust regression approaches 1.0, when the true value is 0.8954, and further,

that the small-sample bias of the robust regression is also unacceptable. The Cressie estimator also has serious asymptotic bias with respect to sample size, but is better behaved with small-sample bias. Still, it would appear that both of these estimators are very poorly behaved with extremely 'heavy-tailed', non-Normal samples such as these. The two estimators that *are* asymptotically unbiased are the moment and MLE estimators, but they are beginning to show larger and larger sub-sample sizes required to reach the true value. Also, as we depart from Normal samples, the small-sample bias of these estimators becomes larger.

Figures 29 and 30 clearly show the biased behavior of the robust regression estimator. This bias is referred to by Denby and Martin, when discussing the "M-estimate," and the "GM-estimate." This robust regression model is the "M-estimate," and hence demonstrates the asymptotic biased behavior referred to by these authors. [Ref. 9, p. 141] The further from Normality the sample distribution becomes (in terms of the l parameter of the l -Laplace distribution and "heavy-tailedness" of the underlying probability distribution), the worse the behavior of these estimators becomes. Figures 31 and 32 are the individual plots for the Cressie estimator. With only three super-replications, we can see good stability in the simulation results (in terms of the standard deviations reported with every statistic in the super-replications summary (Figures 30 and 32)).

Figures 33 through 36 are the individual plots for the two "convergent" estimators, the moment and the MLE estimators. Here, we can begin to compare these and see if perhaps one estimator is becoming unbiased faster than the other (again, with respect to sample size). It appears from Figures 33 and 35 that the MSEs of both estimators are decreasing at about the same rate. The asymptotic regression estimate for the moment estimator (0.9048) is larger than that for the Priestley estimator (0.8941), but the Priestley estimator is underestimating the actual correlation, while the moment estimator is now over-estimating the true value. Both estimators appear to be exhibiting similar behavior. (The reader will undoubtedly note the volume of output required to be analyzed when computers are used to conduct simulations, and hopefully will begin to appreciate the purpose of such a package as SIMTBED.)

4. Parameter $l = 0.1$.

As the final case of the strongly correlated, non-Normal samples on which we estimate serial correlation, the extreme non-Normal case where parameter $l = 0.1$ was run with SIMTBED. The results begin with Figure 37, which is a color combined estimator plot of this simulation. It is clear from Figure 37 that the estimators are split into

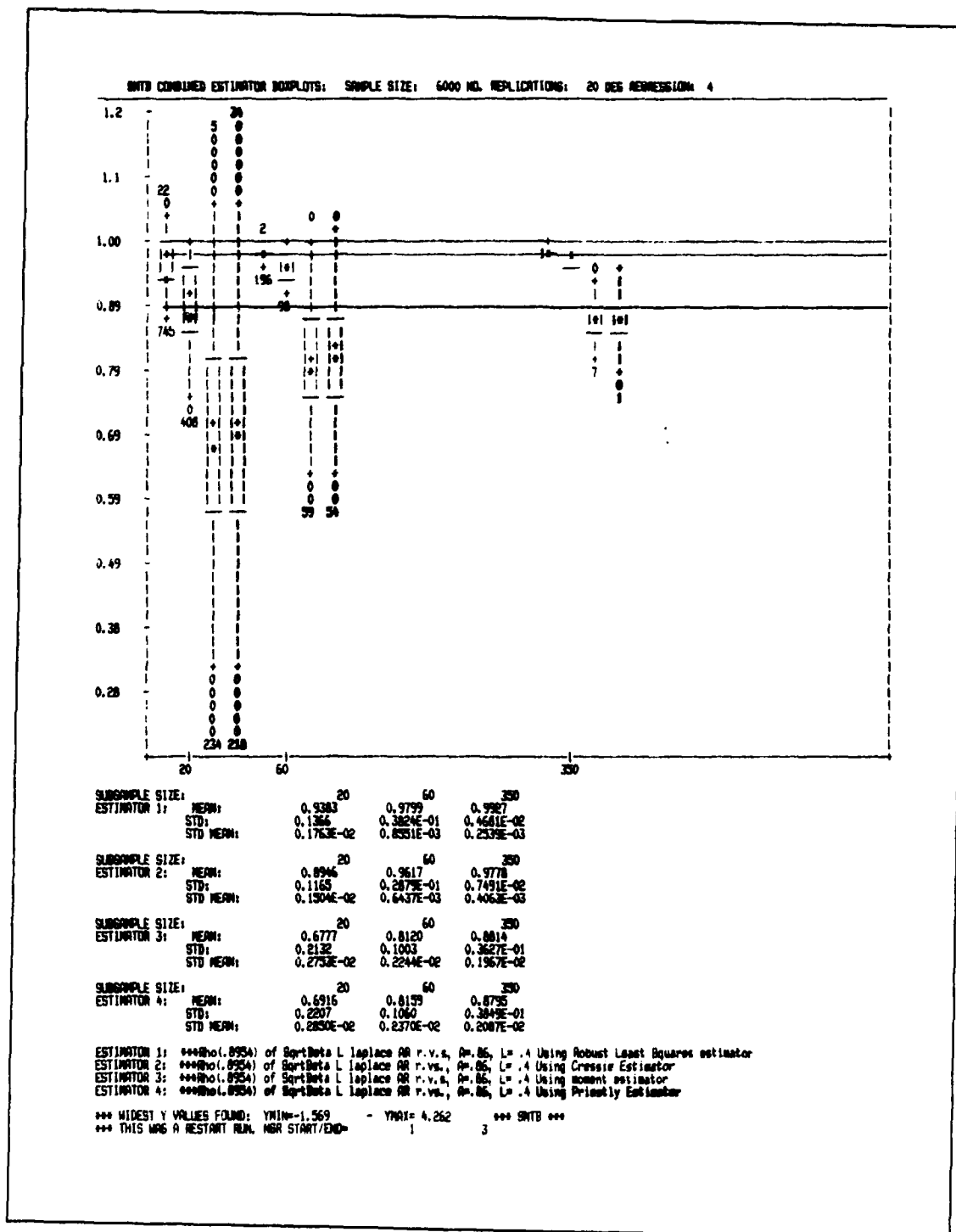


Figure 28. Combined Plot, L-laplace samples. $\rho = 0.8954$, $L = 0.4$.

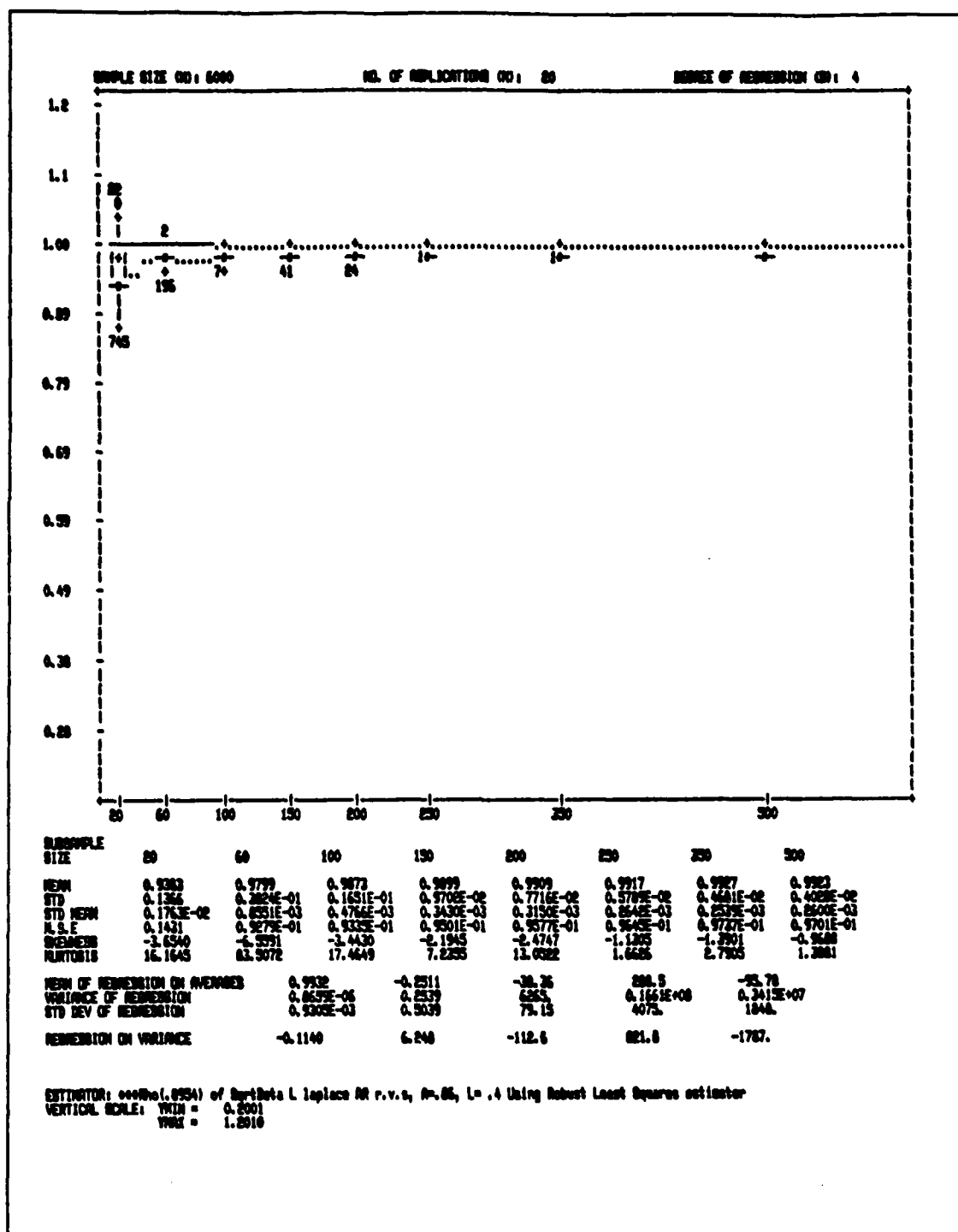


Figure 29. Individual Plot, L-Laplace samples. Robust Least Squares.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	40	100	150	200	250	300	350
MEAN	0.9271 0.6304E-03	0.9283 0.6308E-03	0.9271 0.6323E-04	0.9277 0.6321E-03	0.9277 0.6322E-03	0.9273 0.6323E-03	0.9283 0.6319E-03	0.9285 0.6327E-03
STD	0.1271 0.2732E-03	0.2335E-01 0.3073E-02	0.1732E-01 0.4902E-03	0.1885E-01 0.5331E-03	0.2372E-03 0.2372E-03	0.2372E-03 0.2372E-03	0.2372E-03 0.2372E-03	0.2372E-03 0.2372E-03
R.S.E	0.1432 0.2830E-04	0.2830E-01 0.2830E-03	0.2237E-01 0.7442E-04	0.2237E-01 0.7442E-04	0.2237E-01 0.7442E-04	0.2237E-01 0.7442E-04	0.2237E-01 0.7442E-04	0.2237E-01 0.7442E-04
BIASEDNESS	-3.572 0.4442E-04	-3.594 0.7657	-4.042 0.3019	-2.821 0.3171	-2.627 0.1130	-1.529 0.1659	-1.764 0.4060	-2.922 0.7794E-04
MURTUOSIS	15.22 0.4233	44.23 18.28	27.97 5.209	24.04 2.804	12.97 0.7897	2.997 0.7108	7.239 4.235	1.251 0.4257
REL. COR.	0.2513E-02 0.7873E-02	0.2513E-01 0.1307E-01	-0.2111E-01 0.2602E-02	0.2513E-02 0.2443E-01	-0.2111E-02 0.1247E-01	-0.2111E-02 0.4424E-01	-0.2111E-02 0.2232E-01	0.2513E-01 0.5032E-01
QUANTILES								
0.010	0.2706 0.4504E-02	0.8248 0.1807E-01	0.9123 0.2424E-02	0.9482 0.2018E-02	0.9282 0.4593E-02	0.9702 0.9589E-03	0.9738 0.1032E-02	0.9797 0.1214E-02
0.025	0.4535 0.3537E-02	0.8899 0.3849E-02	0.9418 0.1349E-03	0.9601 0.1472E-02	0.9702 0.7254E-03	0.9762 0.8863E-03	0.9804 0.1032E-02	0.9833 0.4653E-03
0.050	0.6702 0.4078E-02	0.9234 0.2771E-02	0.9581 0.8197E-03	0.9706 0.1164E-02	0.9760 0.5253E-03	0.9804 0.2778E-03	0.9831 0.3500E-03	0.9852 0.5372E-03
0.100	0.8145 0.4148E-02	0.9538 0.1853E-02	0.9711 0.9459E-03	0.9785 0.3947E-03	0.9814 0.1919E-03	0.9838 0.1545E-03	0.9865 0.2322E-03	0.9875 0.2252E-03
0.250	0.9402 0.1412E-02	0.9787 0.3249E-03	0.9837 0.3010E-03	0.9865 0.1753E-03	0.9878 0.4612E-04	0.9886 0.1511E-03	0.9903 0.1705E-03	0.9905 0.2422E-03
0.500	0.9830 0.3947E-03	0.9906 0.6940E-04	0.9916 0.1843E-03	0.9923 0.1784E-03	0.9926 0.5490E-04	0.9928 0.1938E-04	0.9934 0.3813E-04	0.9932 0.1185E-03
0.750	0.9986 0.2067E-03	0.9968 0.2123E-04	0.9964 0.4990E-04	0.9960 0.4869E-04	0.9958 0.1192E-03	0.9957 0.1229E-03	0.9958 0.2588E-04	0.9954 0.1793E-03
0.900	1.008 0.2537E-03	1.001 0.1674E-03	0.9996 0.8004E-05	0.9987 0.7019E-04	0.9982 0.2249E-03	0.9977 0.1900E-03	0.9976 0.3544E-04	0.9979 0.1564E-03
0.950	1.017 0.7537E-03	1.004 0.2724E-03	1.001 0.5344E-05	1.000 0.8422E-04	0.9994 0.2778E-03	0.9987 0.4049E-04	0.9985 0.1622E-03	0.9981 0.1672E-03
0.975	1.029 0.1093E-02	1.007 0.4649E-03	1.003 0.2501E-03	1.002 0.1741E-03	1.000 0.3222E-03	0.9995 0.1201E-03	0.9994 0.1364E-03	0.9987 0.2723E-03
0.990	1.049 0.2144E-02	1.013 0.1655E-03	1.006 0.4328E-03	1.004 0.4489E-03	1.002 0.5962E-03	1.001 0.2115E-03	1.000 0.1863E-03	0.9996 0.1033E-03
MEAN OF REGRESSION ON AVERAGES		0.9940 0.4247E-03	-0.6013 0.2135	-2.989 28.90	-676.6 1579.	-357.7 764.5		
STD DEV OF REGRESSION		0.9613E-03 0.3986E-04	0.5332 0.2387E-01	84.34 2.875	4342. 140.1	1970. 64.06		
REGRESSION ON VARIANCE		-0.4011E-01 0.4940E-01	2.249 2.614	-42.12 47.35	320.9 342.9	-636.1 736.9		
ESTIMATOR: ***rho(.9954) of Squibb's L Laplace RR r.v.s, A=.85, L=.4 Using Robust Least Squares estimator								

Figure 30. Summary Statistics, L-Laplace samples. Robust Least Squares.

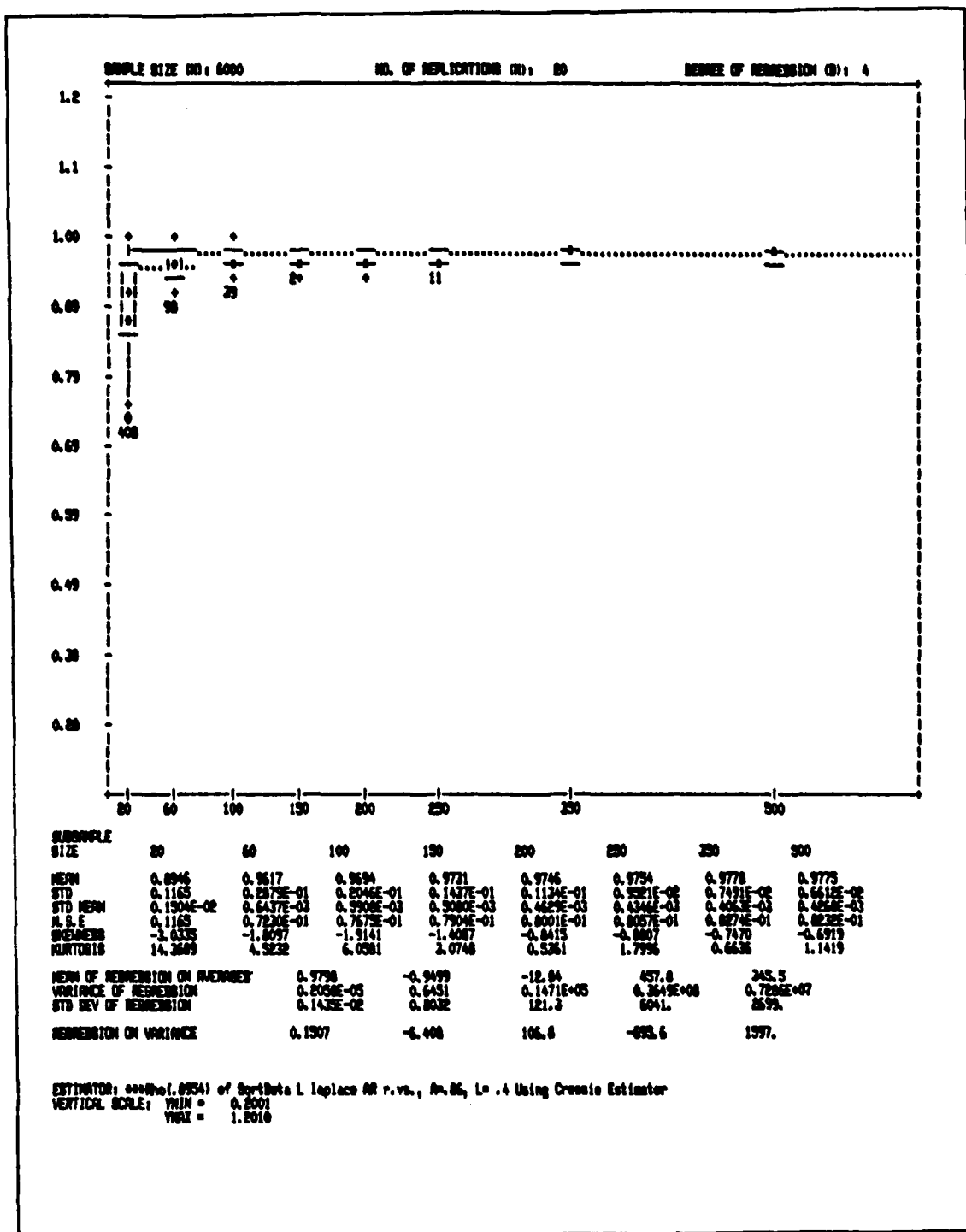


Figure 31. Individual Plot, L-Laplace samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	60	100	150	200	250	300	350
MEAN	0.9935 0.399E-03	0.9813 0.294E-03	0.9702 0.414E-03	0.9730 0.162E-03	0.9730 0.294E-03	0.9734 0.257E-03	0.9709 0.408E-03	0.9775 0.297E-04
STD	0.1218 0.309E-02	0.296E-01 0.163E-02	0.193E-01 0.584E-03	0.141E-01 0.261E-03	0.116E-01 0.181E-03	0.100E-01 0.267E-03	0.097E-02 0.261E-03	0.094E-02 0.219E-04
N.B.E	0.1218 0.310E-02	0.782E-01 0.402E-03	0.772E-01 0.253E-03	0.789E-01 0.122E-03	0.804E-01 0.848E-03	0.808E-01 0.277E-03	0.817E-01 0.444E-03	0.827E-01 0.282E-04
MEAN/STD	-2.319 0.235	-1.951 0.288	-1.588 0.1157	-1.396 0.458E-01	-1.115 0.144	-1.029 0.122	-0.728 0.044E-01	-0.688 0.257E-01
MEAN/STD	22.28 1.951	6.223 2.047	4.627 0.731	2.984 0.234	1.728 0.052	1.087 0.484	0.588 0.282	0.097 0.253
DEV. COV.	-0.130E-02 0.703E-02	-0.163E-01 0.182E-01	-0.730E-02 0.107E-01	-0.670E-01 0.163E-01	-0.773E-02 0.113E-01	-0.120E-01 0.120E-01	-0.020E-01 0.020E-01	-0.210E-01 0.210E-01
QUANTILES								
0.010	0.9980 0.968E-02	0.9905 0.601E-02	0.9902 0.361E-02	0.9850 0.229E-02	0.9800 0.214E-02	0.9813 0.298E-02	0.9888 0.113E-02	0.9902 0.233E-03
0.025	0.9835 0.817E-02	0.9809 0.351E-02	0.9813 0.297E-02	0.9793 0.818E-03	0.9854 0.198E-02	0.9813 0.273E-03	0.9879 0.103E-02	0.9821 0.662E-03
0.050	0.9742 0.344E-02	0.9835 0.154E-02	0.9830 0.712E-03	0.9857 0.613E-03	0.9833 0.672E-03	0.9879 0.185E-02	0.9817 0.136E-02	0.9832 0.786E-03
0.100	0.9790 0.680E-03	0.9824 0.271E-03	0.9851 0.386E-03	0.9844 0.663E-03	0.9890 0.670E-03	0.9827 0.589E-03	0.9838 0.527E-03	0.9834 0.384E-03
0.250	0.9667 0.233E-03	0.9496 0.580E-03	0.9511 0.903E-03	0.9568 0.382E-03	0.9687 0.466E-03	0.9638 0.469E-03	0.9721 0.584E-03	0.9733 0.222E-03
0.500	0.9324 0.194E-03	0.9588 0.663E-03	0.9730 0.112E-03	0.9738 0.262E-03	0.9772 0.362E-03	0.9769 0.407E-03	0.9782 0.531E-03	0.9781 0.176E-03
0.750	0.9667 0.809E-03	0.9819 0.326E-03	0.9838 0.188E-03	0.9830 0.160E-03	0.9834 0.427E-03	0.9828 0.304E-03	0.9827 0.318E-03	0.9884 0.106E-03
0.900	0.9888 0.401E-03	0.9893 0.191E-03	0.9894 0.785E-04	0.9883 0.186E-03	0.9879 0.169E-03	0.9869 0.291E-03	0.9863 0.283E-04	0.9853 0.113E-03
0.950	0.9885 0.225E-03	0.9921 0.638E-04	0.9919 0.358E-03	0.9907 0.178E-03	0.9898 0.451E-03	0.9891 0.191E-03	0.9881 0.198E-03	0.9872 0.344E-03
0.975	0.9918 0.196E-03	0.9929 0.164E-03	0.9933 0.463E-03	0.9921 0.371E-04	0.9911 0.744E-04	0.9903 0.388E-03	0.9899 0.676E-03	0.9887 0.353E-03
0.990	0.9945 0.164E-03	0.9935 0.103E-03	0.9947 0.448E-03	0.9935 0.142E-03	0.9932 0.282E-03	0.9923 0.631E-03	0.9917 0.553E-03	0.9904 0.280E-03
MEAN OF REGRESSION ON AVERAGES		0.9799 0.172E-03	-1.272 0.1905		68.92 45.48	-4932 2738.		-2004. 1280.
STD DEV OF REGRESSION		0.147E-02 0.330E-04	0.7895 0.218E-01		118.2 3.909	2889. 217.2		8535. 108.3
REGRESSION ON VARIANCE		0.347E-01 0.604E-01	-0.8783 2.863		18.23 43.87	-125.3 292.6		421.7 619.8

EXTENSION: ***rho(0.994) of Sp(8)Data L Laplace AR v.v., A=.05, L=.4 Using Cressie Estimator

Figure 32. Summary Statistics, L-Laplace samples. Cressie Estimator.

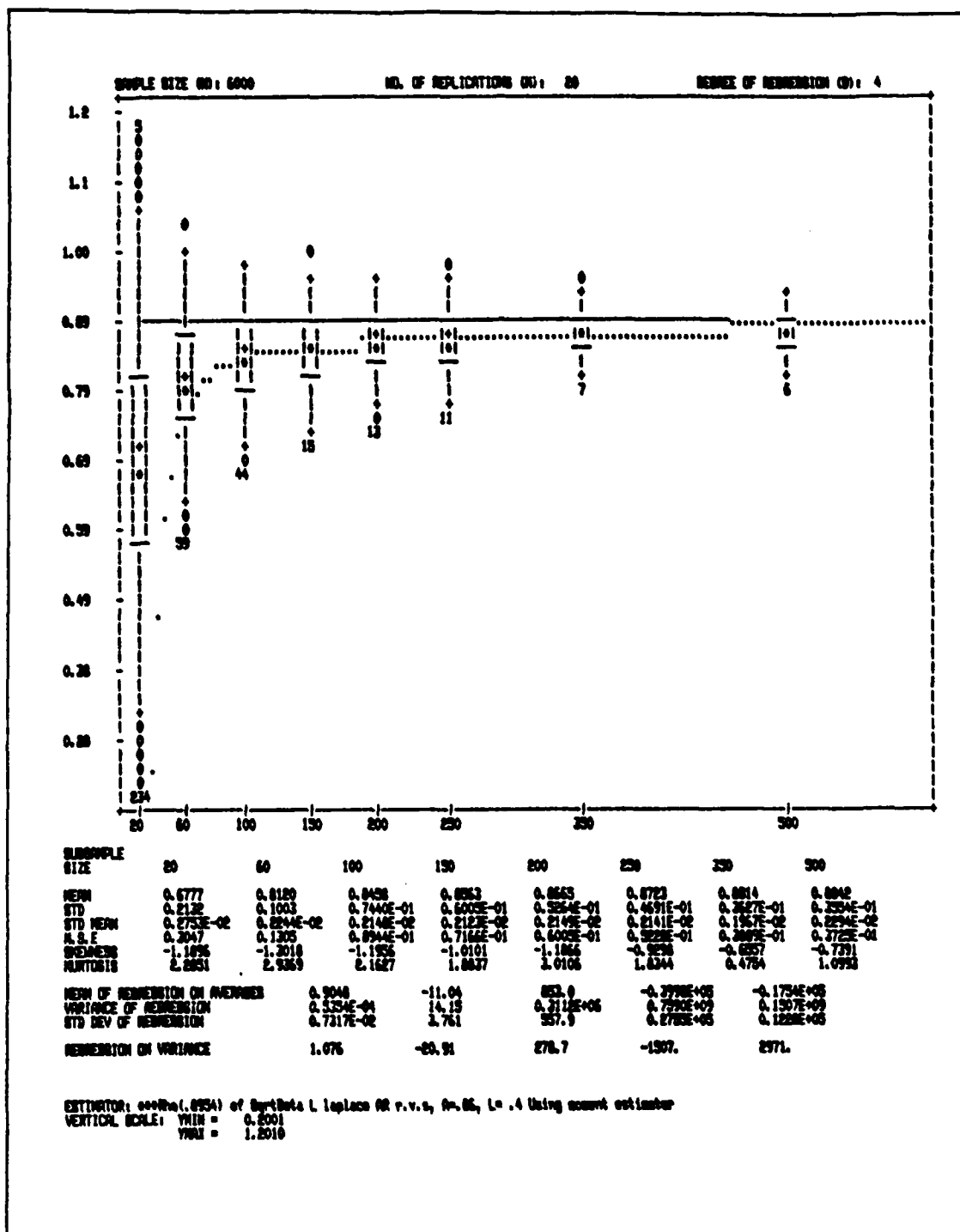


Figure 33. Individual Plot, L-Laplace samples. Moment Estimator.

SUMMARY STATISTICS OVER/STW 3 SUPER-REPLICATIONS								
SUBSAMPLE SIZE	50	60	100	150	200	250	300	350
MEAN	0.6700 0.1911E-02	0.6077 0.1431E-02	0.6484 0.1761E-02	0.6354 0.4364E-03	0.6575 0.6314E-03	0.6702 0.3937E-03	0.6792 0.1192E-02	0.6943 0.1312E-03
STD	0.5092 0.2847E-02	0.1891 0.1912E-02	0.7384E-01 0.3832E-03	0.6970E-01 0.5794E-03	0.9187E-01 0.4332E-03	0.4579E-01 0.5862E-03	0.2678E-01 0.1212E-02	0.2821E-01 0.1332E-02
N.S.E	0.2017 0.3148E-02	0.1399 0.2138E-02	0.9184E-01 0.1093E-02	0.7217E-01 0.3027E-03	0.5889E-01 0.9492E-03	0.5187E-01 0.5502E-03	0.4021E-01 0.1448E-02	0.3473E-01 0.1292E-02
OVERMEAN	-1.234 0.4417E-01	-1.462 0.8152E-01	-1.147 0.2810E-01	-0.9899 0.2873E-01	-1.011 0.0888E-01	-1.054 0.1302	-0.638 0.1153	-0.3218 0.1423
MURTORS	2.415 0.6658	4.425 0.7793	2.489 0.2223	1.356 0.1604	2.289 0.2921	2.893 1.074	0.993 0.9923	0.883 0.1423
REL.COR.	0.1971E-02 0.9774E-02	-0.1891E-01 0.4317E-02	-0.1737E-02 0.2223E-01	-0.1112E-01 0.1662E-01	-0.2817E-01 0.2817E-01	-0.5317E-01 0.5317E-01	-0.2817E-01 0.2817E-01	-0.2817E-01 0.2817E-01
QUANTILES								
0.010	0.1745E-01 0.1192E-01	0.4673 0.9532E-02	0.6081 0.7823E-02	0.6710 0.2910E-02	0.7104 0.4027E-02	0.7285 0.1237E-02	0.7694 0.0482E-02	0.7942 0.0708E-02
0.025	0.1445 0.1493E-01	0.3922 0.1178E-01	0.6364 0.6153E-02	0.7117 0.3634E-02	0.7468 0.4332E-02	0.7657 0.2512E-02	0.7774 0.6362E-02	0.8102 0.8342E-02
0.050	0.2706 0.1238E-01	0.6185 0.2814E-02	0.7089 0.4663E-02	0.7439 0.3032E-02	0.7757 0.3092E-02	0.7911 0.3092E-02	0.8125 0.4822E-02	0.8273 0.5364E-02
0.100	0.4034 0.3932E-02	0.6763 0.2001E-02	0.7498 0.1674E-02	0.7748 0.7604E-03	0.8007 0.1166E-02	0.8149 0.2342E-02	0.8277 0.2122E-02	0.8430 0.2304E-02
0.250	0.5730 0.1214E-02	0.7937 0.1241E-02	0.8038 0.3524E-02	0.8234 0.1144E-02	0.8372 0.2002E-02	0.8469 0.5481E-03	0.8583 0.1582E-02	0.8637 0.3822E-03
0.500	0.7184 0.9365E-03	0.8299 0.1055E-02	0.8530 0.2866E-02	0.8630 0.9500E-03	0.8738 0.1305E-02	0.8753 0.9532E-03	0.8834 0.1738E-02	0.8899 0.8212E-03
0.750	0.8894 0.2220E-02	0.8825 0.1063E-03	0.8953 0.1695E-02	0.8998 0.5472E-03	0.9039 0.2689E-03	0.9058 0.4503E-03	0.9040 0.9161E-03	0.9080 0.8162E-03
0.900	0.8967 0.1318E-02	0.9177 0.2028E-03	0.9241 0.7723E-03	0.9260 0.1263E-02	0.9282 0.2907E-03	0.9244 0.6382E-03	0.9223 0.1482E-02	0.9244 0.1414E-02
0.950	0.9388 0.2298E-02	0.9260 0.1354E-03	0.9385 0.3640E-03	0.9372 0.1602E-02	0.9379 0.2342E-02	0.9354 0.2387E-02	0.9327 0.1542E-02	0.9346 0.1492E-02
0.975	0.9737 0.2592E-02	0.9303 0.7772E-03	0.9514 0.4390E-03	0.9477 0.1182E-02	0.9494 0.2847E-02	0.9437 0.2562E-02	0.9435 0.2252E-02	0.9418 0.1900E-02
0.990	1.019 0.3942E-02	0.9671 0.1739E-02	0.9642 0.1773E-02	0.9575 0.1123E-02	0.9588 0.2148E-02	0.9519 0.2982E-02	0.9496 0.2222E-02	0.9503 0.2112E-02
MEAN OF REGENERATION ON AVERAGES		0.8994 0.2727E-02	-0.065 1.583		270.7 562.3	-0.1990E+05 0.1313E+05	-6889. 5858.	
STD DEV OF REGENERATION		0.6854E-02 0.2440E-03	3.306 0.1347		519.0 19.46	0.2382E+05 959.9	0.1142E+05 443.9	
REGENERATION ON VARIANCE		0.2302 0.5168	12.87 21.70		-880.0 219.3	1544. 1538.	-3453. 4025.	
EXTIMATOR: ***rho(.0934) of Bernoulli L Laplace RR r.v.s, R=.05, L=.4 Using moment estimator								

Figure 34. Summary Statistics, L-Laplace samples. Moment Estimator.

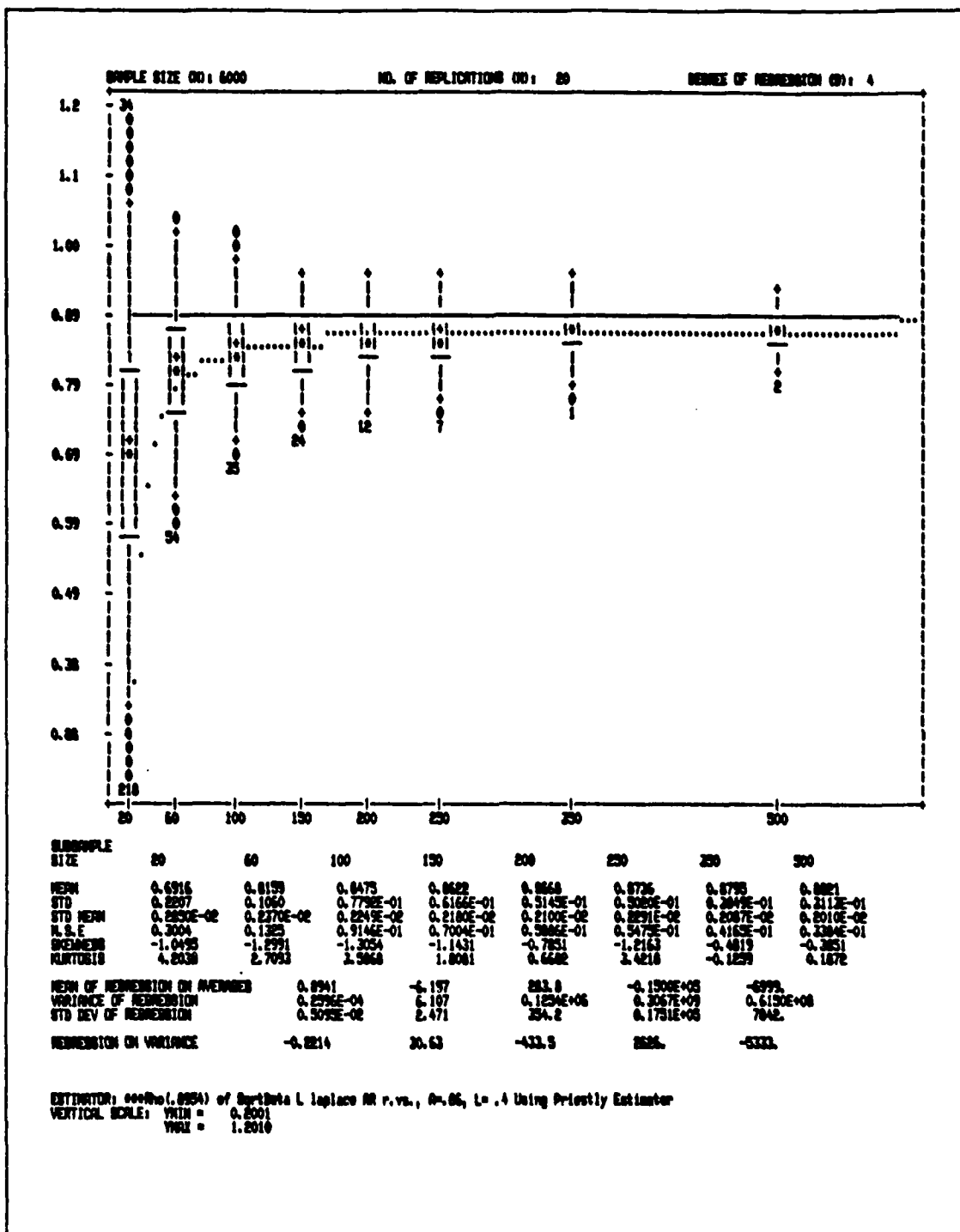


Figure 35. Individual Plot, L-Laplace samples. Priestley Estimator.

SUMMARY STATISTICS (MEAN/STD) 3 SUPER-REPLICATIONS								
SAMPLE SIZE	20	60	100	130	200	250	350	500
MEAN	0.0922 0.1992E-02	0.0173 0.1002E-02	0.0465 0.6382E-03	0.0513 0.8907E-03	0.0572 0.2472E-03	0.0747 0.3932E-03	0.0793 0.8042E-03	0.0943 0.2042E-02
STD	0.0179 0.1521E-02	0.1045 0.7617E-03	0.7794E-01 0.9092E-03	0.6122E-01 0.4922E-03	0.2112E-01 0.5072E-03	0.4792E-01 0.1382E-02	0.7792E-01 0.1982E-02	0.7172E-01 0.1912E-02
M.S.E	0.0980 0.2172E-02	0.1205 0.1081E-02	0.9162E-01 0.1044E-02	0.7011E-01 0.7612E-03	0.3832E-01 0.6012E-03	0.2172E-01 0.1492E-02	0.4392E-01 0.1762E-02	0.2272E-01 0.2212E-02
BIAS/MEAN	-0.6748 0.3461	-1.309 0.1802E-01	-1.212 0.1067	-1.077 0.4532E-01	-0.7717 0.4092E-01	-1.089 0.9142E-01	-0.7998 0.1853	-0.5149 0.1386
MURTOSIS	7.173 2.704	2.002 0.1793	2.277 0.6367	1.632 0.2451	0.6999 0.1023	0.446 0.7007	1.071 0.6361	0.0535 0.6352
RED. COV.	-0.7771E-02 0.8092E-02	-0.8292E-02 0.2252E-01	-0.2777E-02 0.7794E-02	-0.3702E-02 0.1212E-01	-0.2202E-01 0.1872E-01	-0.0821E-01 0.1732E-01	-0.1702E-01 0.2342E-01	-0.4092E-03 0.4422E-01
QUANTILES								
0.010	0.2902E-01 0.5127E-02	0.4773 0.1822E-01	0.5973 0.1112E-01	0.0578 0.9300E-02	0.7097 0.2291E-02	0.7271 0.4341E-02	0.7344 0.1232E-01	0.7918 0.1072E-01
0.025	0.1635 0.6942E-02	0.3519 0.2401E-02	0.6579 0.7570E-02	0.7061 0.3901E-02	0.7463 0.2702E-02	0.7632 0.8022E-02	0.7825 0.2971E-02	0.8189 0.4812E-02
0.050	0.2814 0.1212E-01	0.6210 0.3962E-02	0.7015 0.2252E-02	0.7437 0.2442E-02	0.7743 0.4652E-02	0.7888 0.5262E-02	0.8053 0.7377E-02	0.8293 0.6582E-02
0.100	0.4141 0.5782E-02	0.6785 0.1132E-02	0.7447 0.2842E-02	0.7817 0.1727E-02	0.7982 0.6292E-03	0.8129 0.2212E-02	0.8274 0.2822E-02	0.8418 0.2857E-02
0.250	0.5853 0.2547E-02	0.7661 0.1712E-02	0.8075 0.9922E-03	0.8285 0.2182E-02	0.8366 0.1242E-03	0.8479 0.2117E-02	0.8564 0.1632E-02	0.8649 0.2932E-02
0.500	0.7294 0.6231E-03	0.8367 0.5732E-03	0.8605 0.5234E-03	0.8730 0.1412E-02	0.8743 0.1042E-02	0.8823 0.1018E-02	0.8843 0.2041E-02	0.8861 0.2002E-02
0.750	0.8312 0.1232E-03	0.8922 0.5014E-03	0.9006 0.2342E-03	0.9053 0.6194E-03	0.9036 0.3992E-03	0.9088 0.8932E-03	0.9080 0.9832E-03	0.9063 0.1212E-02
0.900	0.9157 0.1410E-02	0.9271 0.2262E-02	0.9294 0.1657E-02	0.9288 0.7192E-03	0.9273 0.1114E-02	0.9281 0.5142E-03	0.9251 0.1892E-02	0.9230 0.1932E-02
0.950	0.9636 0.1012E-02	0.9431 0.2122E-02	0.9443 0.1202E-02	0.9398 0.1301E-02	0.9380 0.5002E-03	0.9391 0.1147E-02	0.9340 0.2261E-02	0.9334 0.6352E-03
0.975	1.006 0.9600E-03	0.9609 0.2362E-02	0.9351 0.9767E-03	0.9490 0.1232E-02	0.9460 0.4722E-03	0.9468 0.1002E-02	0.9444 0.2862E-02	0.9408 0.9812E-03
0.990	1.080 0.9531E-02	0.9832 0.2842E-02	0.9700 0.2062E-02	0.9579 0.1132E-02	0.9564 0.2172E-02	0.9548 0.1444E-02	0.9560 0.2262E-02	0.9480 0.2172E-02
MEAN OF REGRESSION ON AVERAGES		0.0968 0.3342E-02	-6.769 1.514		280.0 227.1	-0.1216E+05 0.1177E+05	-3242. 5380.	
STD DEV OF REGRESSION		0.6000E-02 0.6609E-03	3.026 0.2539		444.5 35.04	0.2202E+05 2764.	9859. 1234.	
REGRESSION ON VARIANCE		0.9531 0.7454	-2.307 31.71		52.19 464.7	-845.6 8826.	472.9 5802.	

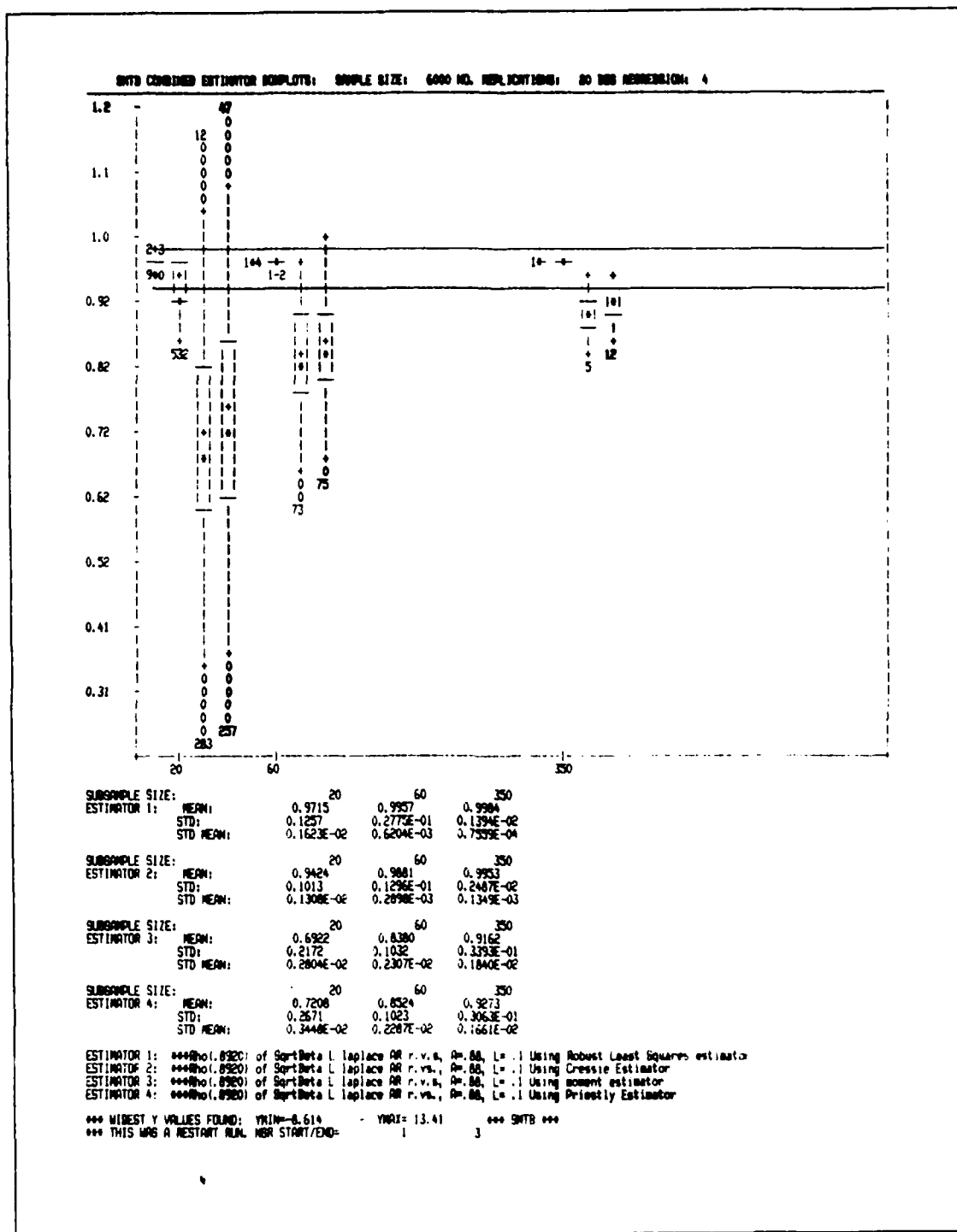
ESTIMATOR: ***rho(.0954) of Squared L Laplace RR r.v., $\theta=.66$, $L=.4$ Using Priestly Estimator

Figure 36. Summary Statistics, L-Laplace samples. Priestley Estimator.

two distinct classes: the robust regression and the Cressie estimator comprise one group, and the moment and MLE estimators comprise the other. The first group is strongly biased, while the second group converges, but with slower and slower progress, as this particular sample distribution (BELAR(1)) becomes more extreme. Recall that when the parameter l is small, and the samples are correlated, the behavior of the sample stream is such that there are long runs of numbers very close to zero, and then peaks of a few positive (or negative) numbers are interspersed. Figure 38 shows the unacceptably biased behavior of the robust regression, and Figure 39 has the super-replications summary for this estimator's run. Figures 40 and 41 show the similar behavior for the Cressie estimator. Recall that the Cressie estimator showed very sensitive behavior with respect to Normality, in that it immediately began to show bias when l was set to three. Figures 42 and 43 represent the moment estimator. One might say, without the previous simulation results, that this estimator also is exhibiting bias, but I would comment that the MSE is still decreasing at sub-sample size 500, and is still roughly twice the corresponding standard deviation, so it is possible that this estimator is converging, but very slowly. The same comments apply to the MLE estimator, results for which are in Figures 44 and 45.

5. Large-Sample Simulation with Robust Regression.

Before presenting the results on the simulation involving the uncorrelated BELAR(1) processes, we present the results for a large-sample simulation involving the robust regression. It was desired to determine if the robust regression estimator was actually converging, but in the process it might have been actually deviating more from the true value for some range of sample sizes. In other words, we were investigating the possibility of a non-monotonic convergence to the true correlation value. To do this, we ran a SIMTBED simulation with only the robust regression estimator, and used very large sample sizes, as can be seen in Figure 46. Here, sub-sample sizes up to and including 5000 were used, with the overall sample size for the simulation increased to 10000, and the number of replications increase to 50. Thus, at sub-sample size 5000, there are 200 evaluations of the estimator represented by that boxplot. This seemed an acceptable minimum number of estimator evaluations. Figure 46 shows that there is apparently no convergence, even at this extreme, and Figure 47 contains the super-replications summary statistics, for three super-replications. The parameter l used was 0.4, a midranged value that did not cause any problems, and the simulation was conducted on two separate versions of the robust regression estimator: one, with no additional scaling, and the other, with the 0.6745 scaling, referred to in Chapter IV, and used



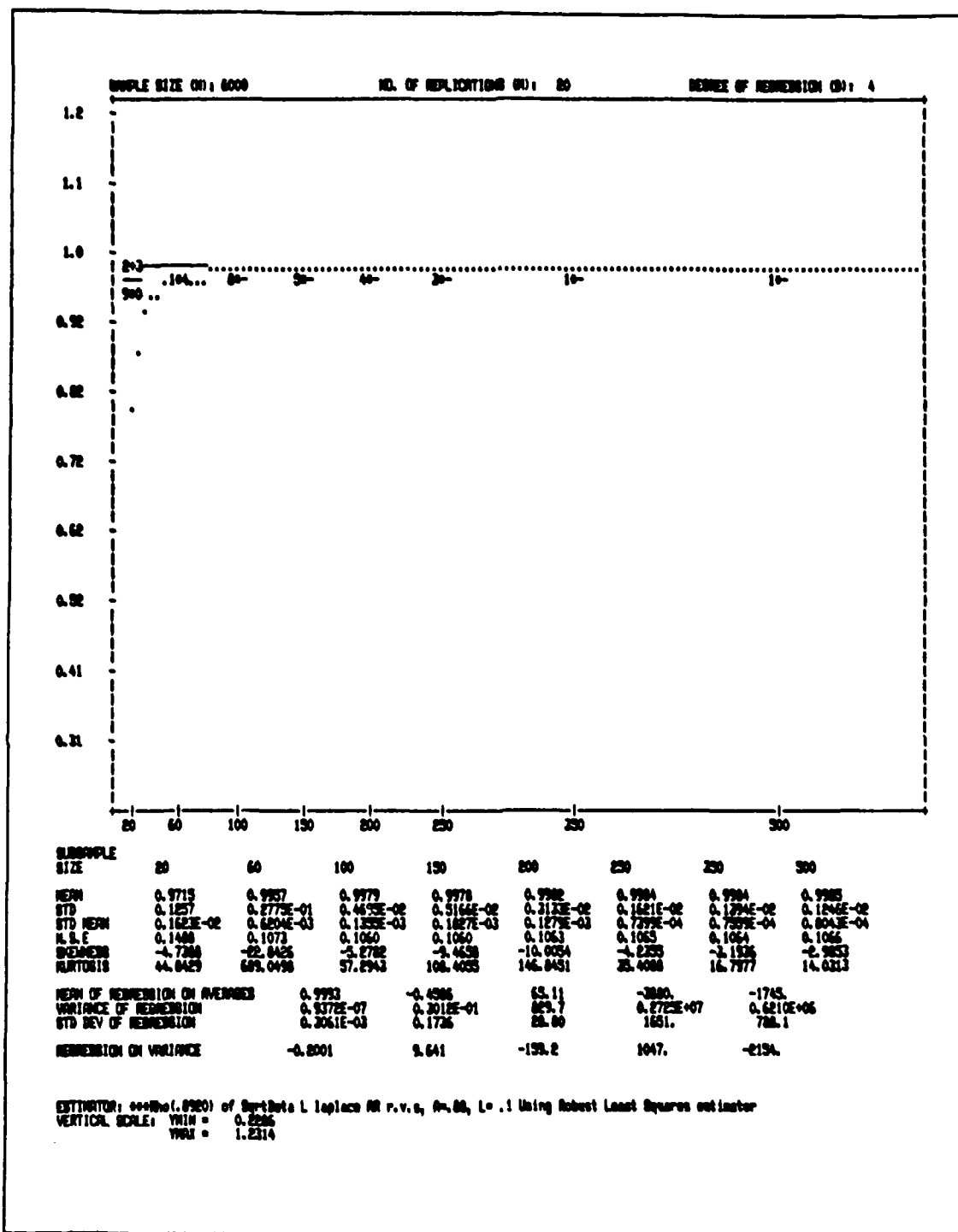


Figure 38. Individual Plot, L-Laplace samples. Robust Least Squares.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	40	100	150	200	250	300	300
MEAN	0.9712 0.542E-03	0.9720 0.553E-04	0.9778 0.125E-03	0.9779 0.601E-04	0.9784 0.761E-04	0.9784 0.451E-04	0.9784 0.287E-04	0.9785 0.120E-04
STD	0.122E 0.674E-03	0.214E-01 0.265E-02	0.374E-02 0.711E-03	0.473E-02 0.240E-03	0.523E-02 0.287E-03	0.177E-02 0.130E-03	0.127E-02 0.274E-04	0.116E-02 0.140E-04
M.S.E	0.148E 0.374E-03	0.1061 0.613E-03	0.1077 0.634E-04	0.1060 0.561E-04	0.1064 0.608E-04	0.1064 0.430E-04	0.1064 0.283E-04	0.1065 0.130E-04
BIASNESS	-1.757 0.672E	-15.01 1.52E	-0.405 1.567	-0.849 0.757E	-7.071 1.527	-1.780 0.418E	-2.024 0.271E	-2.201 0.428E
KURTOSIS	46.85 2.054	238.1 177.3	113.8 88.17	84.13 14.48	81.41 21.42	84.47 0.885	16.75 2.43E	16.13 2.62E
SEMI-COR.	-0.804E-02 0.767E-02	-0.177E-01 0.713E-02	-0.764E-02 0.194E-02	-0.289E-01 0.282E-01	-0.403E-01 0.747E-01	-0.064E-02 0.114E-01	-0.602E-01 0.174E-01	-0.267E-01 0.541E-01
QUANTILES								
0.010	0.8227 0.1897E-01	0.9235 0.146E-02	0.9720 0.456E-02	0.9785 0.2491E-02	0.9785 0.0932E-03	0.9782 0.0967E-03	0.9784 0.488E-03	0.9785 0.643E-03
0.025	0.8248 0.364E-02	0.9715 0.118E-02	0.9874 0.253E-03	0.9912 0.426E-03	0.9937 0.47E-03	0.9945 0.546E-03	0.9951 0.122E-03	0.9956 0.132E-03
0.050	0.8293 0.356E-02	0.9872 0.607E-03	0.9928 0.178E-03	0.9941 0.203E-03	0.9953 0.290E-03	0.9956 0.293E-03	0.9963 0.746E-04	0.9963 0.146E-03
0.100	0.9357 0.244E-02	0.9930 0.238E-03	0.9992 0.1251E-03	0.9960 0.196E-03	0.9967 0.753E-04	0.9968 0.1637E-03	0.9970 0.312E-04	0.9972 0.963E-04
0.250	0.9930 0.2871E-03	0.9971 0.312E-04	0.9976 0.587E-04	0.9978 0.104E-03	0.9979 0.5461E-04	0.9980 0.461E-04	0.9979 0.844E-04	0.9981 0.530E-04
0.500	0.9991 0.390E-04	0.9990 0.2071E-04	0.9990 0.400E-04	0.9989 0.253E-04	0.9989 0.297E-04	0.9988 0.409E-04	0.9987 0.194E-04	0.9988 0.298E-04
0.750	1.001 0.354E-04	0.9999 0.208E-04	0.9997 0.218E-04	0.9995 0.230E-04	0.9995 0.189E-04	0.9994 0.2671E-04	0.9993 0.219E-04	0.9992 0.101E-04
0.900	1.005 0.130E-03	1.001 0.146E-04	1.000 0.171E-04	1.0000 0.126E-04	0.9999 0.128E-04	0.9998 0.206E-04	0.9997 0.187E-04	0.9996 0.106E-04
0.950	1.010 0.487E-04	1.002 0.672E-04	1.001 0.6691E-04	1.000 0.345E-04	1.000 0.140E-04	0.9999 0.147E-04	0.9998 0.290E-04	0.9997 0.141E-04
0.975	1.019 0.5671E-03	1.003 0.298E-04	1.001 0.7207E-04	1.000 0.415E-04	1.000 0.6147E-04	1.000 0.303E-05	1.0000 0.809E-04	0.9999 0.308E-05
0.990	1.029 0.118E-02	1.004 0.160E-03	1.002 0.221E-03	1.001 0.577E-04	1.001 0.721E-04	1.000 0.602E-04	1.000 0.815E-04	1.0000 0.202E-04
MEAN OF REGRESSION ON AVERAGES		0.9989 0.2287E-03	-0.2135 0.144E		24.89 22.82	-1771. 1277.	-781.7 562.9	
STD DEV OF REGRESSION		0.2987E-03 0.273E-04	0.1737 0.161E-01		28.86 2.343	1537. 125.2	715.7 62.86	
REGRESSION ON VARIANCE		-0.822E-01 0.583E-01	2.905 2.868		-62.77 48.21	292.3 227.2	-631.1 731.6	

EXTORTION: ***hel(.8920) of SupData L Laplace RR p.v.s, R= .88, L= .1 Using Robust Least Squares estimator

Figure 39. Summary Statistics, L-Laplace samples. Robust Least Squares.

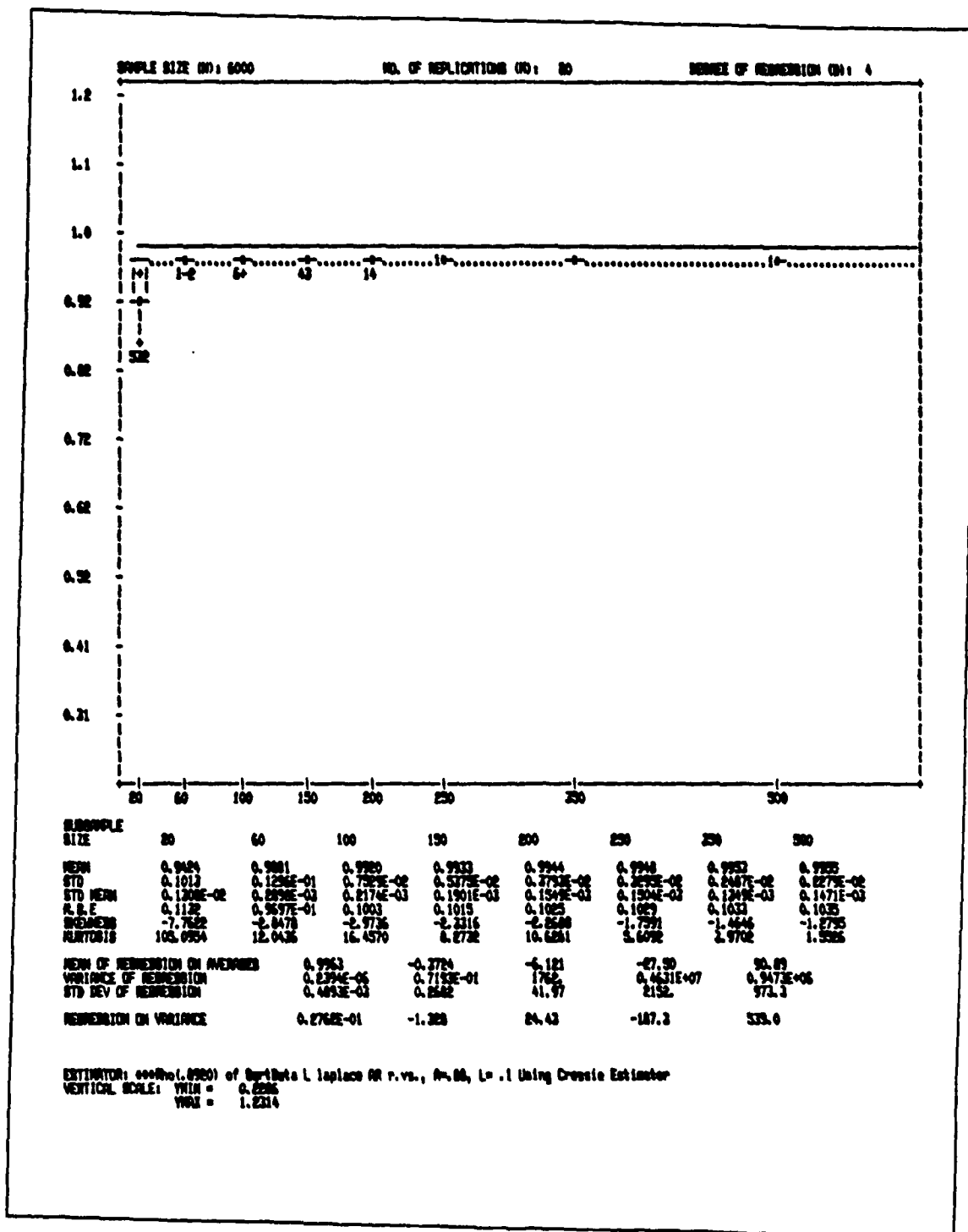


Figure 40. Individual Plot, L-Laplace samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)				3 SUPER-REPLICATIONS			
	20	60	100	130	200	230	250	300
MEAN	0.9405 0.9405E-03	0.9880 0.8435E-03	0.9919 0.6044E-04	0.9925 0.1793E-03	0.9943 0.2502E-04	0.9948 0.5827E-04	0.9953 0.8898E-04	0.9955 0.1109E-03
STD	0.1080 0.1200E-02	0.1202E-01 0.8533E-03	0.7400E-02 0.1900E-03	0.4971E-02 0.1700E-03	0.4000E-02 0.1700E-03	0.2717E-02 0.1211E-03	0.2013E-02 0.4313E-04	0.2074E-02 0.1213E-03
N.S.E	0.1120 0.1211E-02	0.9594E-01 0.8762E-03	0.1002 0.7414E-04	0.1010 0.1700E-03	0.1004 0.7400E-04	0.1000 0.6400E-04	0.1003 0.6533E-04	0.1005 0.7007E-03
BIASNESS	-7.509 1.179	-2.123 0.1048	-0.437 0.3107	-0.089 0.1451	-0.070 0.8540E-01	-1.787 0.1204	-1.404 0.1714	-1.470 0.4614E-01
KURTOSIS	114.8 42.54	15.21 2.120	10.89 2.473	6.204 1.028	7.894 1.537	3.208 0.8289	4.825 0.6483	0.570 0.6541
SER. COR.	-0.1101E-01 0.4221E-02	-0.5700E-02 0.4222E-02	-0.2817E-02 0.8243E-02	-0.2100E-01 0.1741E-01	-0.7723E-01 0.1264E-01	-0.1600E-01 0.1600E-01	-0.0401E-01 0.5491E-01	-0.1003E-01 0.6622E-01
SUBFILES								
0.010	0.9479 0.1460E-01	0.9346 0.1060E-02	0.9642 0.7932E-03	0.9745 0.1706E-02	0.9793 0.1244E-02	0.9827 0.7853E-03	0.9839 0.8590E-03	0.9863 0.6302E-03
0.025	0.9599 0.6400E-02	0.9516 0.1700E-02	0.9718 0.1690E-03	0.9801 0.7840E-03	0.9839 0.1067E-02	0.9859 0.3057E-03	0.9888 0.2041E-03	0.9901 0.6313E-03
0.050	0.7858 0.4643E-02	0.9624 0.1083E-02	0.9772 0.2803E-03	0.9842 0.6540E-03	0.9868 0.7659E-03	0.9885 0.5680E-03	0.9910 0.5489E-04	0.9915 0.6903E-03
0.100	0.8594 0.3920E-02	0.9739 0.8169E-03	0.9806 0.2729E-03	0.9875 0.4370E-04	0.9896 0.2569E-03	0.9907 0.2497E-03	0.9922 0.4819E-04	0.9930 0.3052E-03
0.230	0.9336 0.7610E-03	0.9851 0.2619E-03	0.9894 0.1814E-03	0.9918 0.1954E-03	0.9927 0.2259E-03	0.9933 0.8534E-04	0.9940 0.1490E-03	0.9945 0.1129E-03
0.300	0.9717 0.4111E-03	0.9921 0.9027E-04	0.9942 0.1590E-04	0.9950 0.1194E-03	0.9954 0.1429E-04	0.9955 0.6800E-04	0.9957 0.6390E-04	0.9960 0.1280E-03
0.750	0.9883 0.1920E-03	0.9961 0.5869E-04	0.9968 0.2537E-04	0.9970 0.1190E-03	0.9971 0.3440E-04	0.9971 0.1077E-03	0.9971 0.1240E-04	0.9971 0.6522E-04
0.900	0.9948 0.9667E-04	0.9980 0.5390E-04	0.9984 0.4493E-04	0.9982 0.1184E-03	0.9981 0.4054E-04	0.9981 0.1540E-04	0.9980 0.6691E-04	0.9978 0.2074E-04
0.930	0.9968 0.1687E-04	0.9987 0.4160E-04	0.9989 0.3351E-04	0.9986 0.8959E-04	0.9986 0.4184E-04	0.9985 0.3437E-04	0.9984 0.8994E-04	0.9982 0.2256E-04
0.975	0.9979 0.1701E-04	0.9990 0.4454E-04	0.9992 0.3104E-04	0.9990 0.6240E-04	0.9989 0.3441E-04	0.9989 0.2800E-04	0.9987 0.4590E-04	0.9985 0.5719E-04
0.990	0.9987 0.3739E-04	0.9993 0.1856E-04	0.9995 0.3444E-04	0.9993 0.5443E-04	0.9992 0.2231E-04	0.9992 0.1781E-04	0.9990 0.9981E-04	0.9987 0.7232E-04
MEAN OF REGRESSION ON AVERAGES		0.9963 0.5359E-03	-0.3382 0.2504	-11.37 42.18		208.6 2196.	200.3 933.8	
STD DEV OF REGRESSION			0.3007E-03 0.2893E-04	0.2781 0.8730E-02	42.43 0.8919	2148. 29.63	963.3 10.14	
REGRESSION ON VARIANCE		0.1783E-01 0.1193E-01	-0.8824 0.5372	17.43 8.222		-142.1 50.37	446.2 101.9	
ESTIMATOR: ***rho(.0980) of SqrdData L Laplace RR P.v.s., R=.88, L=.1 Using Cressie Estimator								

Figure 41. Summary Statistics, L-Laplace samples. Cressie Estimator.

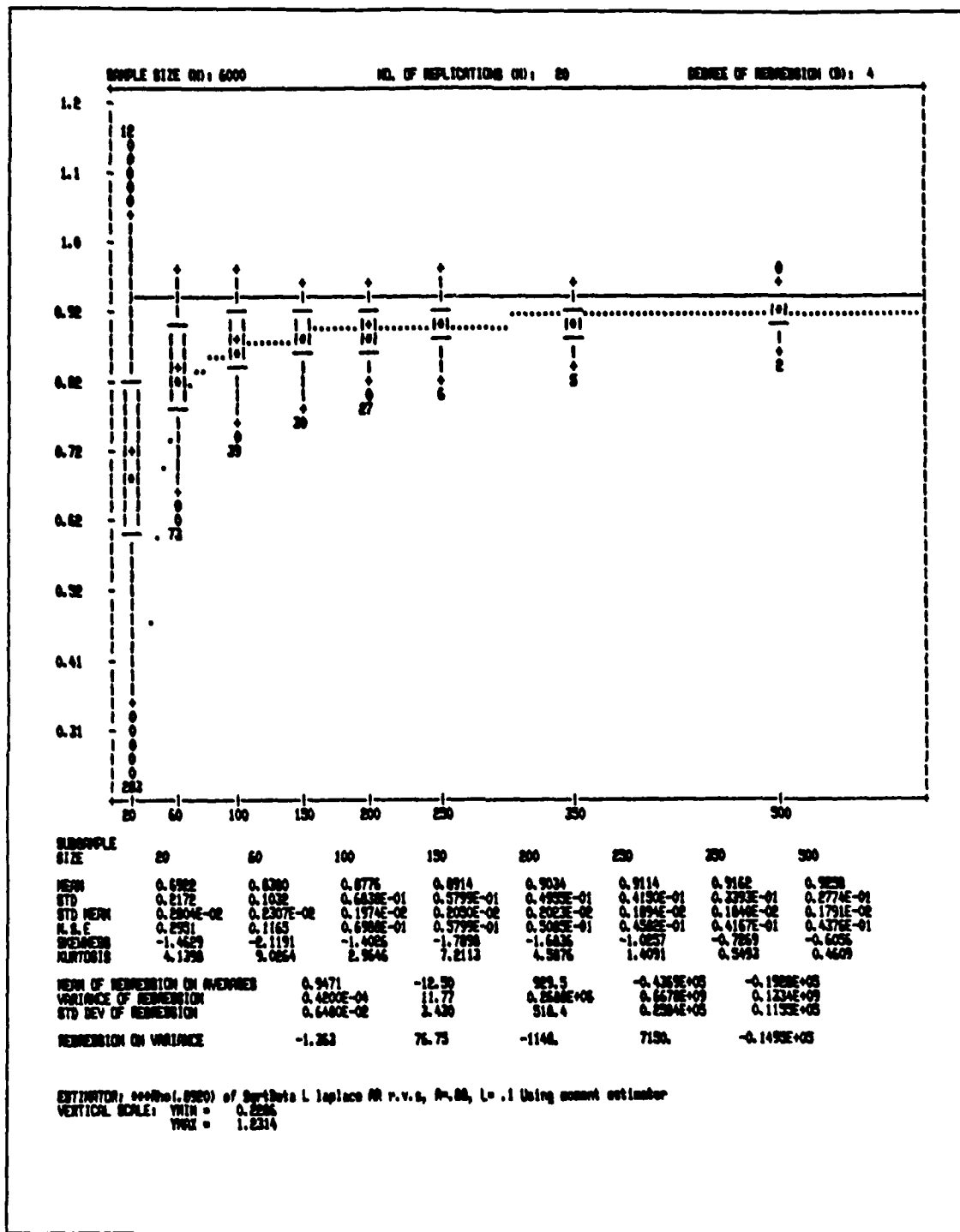


Figure 42. Individual Plot, L-Laplace samples. Moment Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	40	100	130	200	230	250	300
MEAN	0.6911 0.7457E-03	0.6390 0.7583E-03	0.6751 0.1288E-02	0.6934 0.1738E-02	0.9033 0.1065E-03	0.9107 0.6700E-03	0.9177 0.7680E-03	0.9246 0.7333E-03
STD	0.2163 0.6913E-03	0.1619 0.2746E-02	0.7213E-01 0.1913E-02	0.3723E-01 0.2291E-02	0.4761E-01 0.1250E-02	0.4043E-01 0.7383E-03	0.2333E-01 0.7274E-03	0.2741E-01 0.2333E-03
N.S.E	0.2932 0.9023E-03	0.1149 0.2768E-02	0.7413E-01 0.2148E-02	0.3723E-01 0.2291E-02	0.4093E-01 0.1853E-02	0.4493E-01 0.6867E-03	0.4374E-01 0.1634E-02	0.4863E-01 0.5873E-03
BIASNESS	-1.424 0.4621E-01	-1.902 0.1153	-1.628 0.1313	-1.672 0.1779	-1.460 0.1423	-1.637 0.1218E-01	-1.169 0.2269	-0.7660 0.6873E-01
KURTOSIS	2.469 0.2648	6.877 1.081	4.389 0.3832	5.171 1.277	2.767 0.6313	1.608 0.1038	2.817 1.488	0.7175 0.8942
SKW.COEF.	-0.7540E-02 0.6388E-02	-0.2623E-01 0.1601E-01	-0.1903E-01 0.1521E-02	-0.2623E-02 0.1613E-01	0.1637E-02 0.2380E-01	0.1206E-01 0.1631E-01	-0.1633E-01 0.4430E-01	-0.4494E-01 0.1798E-01
QUANTILES								
0.010	-0.1294E-01 0.8736E-02	0.4857 0.1970E-01	0.6249 0.3939E-02	0.6903 0.2633E-01	0.7282 0.8933E-02	0.7827 0.2613E-02	0.8067 0.7611E-02	0.8412 0.7241E-02
0.025	0.3283E-01 0.5890E-02	0.5818 0.1423E-01	0.6919 0.3960E-02	0.7439 0.5882E-02	0.7842 0.7333E-02	0.8142 0.2814E-02	0.8304 0.6251E-03	0.8629 0.5763E-03
0.050	0.8459 0.7763E-02	0.6494 0.7443E-02	0.7291 0.6384E-02	0.7851 0.6314E-02	0.8188 0.2623E-02	0.8351 0.3494E-02	0.8533 0.4891E-02	0.8739 0.5873E-03
0.100	0.4118 0.3876E-02	0.7123 0.5133E-02	0.7831 0.2507E-02	0.8241 0.2000E-02	0.8433 0.2380E-02	0.8568 0.1727E-02	0.8708 0.1600E-02	0.8888 0.1301E-02
0.250	0.6007 0.1193E-02	0.7940 0.1683E-02	0.8430 0.1214E-02	0.8693 0.2570E-02	0.8802 0.4723E-03	0.8876 0.2211E-03	0.8996 0.2041E-02	0.9078 0.1743E-03
0.500	0.7406 0.2917E-03	0.8621 0.7233E-03	0.8902 0.1352E-02	0.9040 0.1253E-02	0.9129 0.1519E-02	0.9177 0.1145E-02	0.9242 0.1861E-02	0.9274 0.3303E-03
0.750	0.8330 0.5781E-03	0.9093 0.4623E-03	0.9253 0.3157E-03	0.9326 0.1176E-02	0.9362 0.4219E-03	0.9404 0.9306E-03	0.9460 0.5323E-03	0.9446 0.1528E-02
0.900	0.9083 0.8733E-03	0.9383 0.1163E-02	0.9479 0.4996E-03	0.9523 0.9458E-03	0.9532 0.6530E-03	0.9561 0.4437E-03	0.9573 0.8103E-03	0.9579 0.5156E-03
0.950	0.9413 0.1086E-02	0.9516 0.9114E-03	0.9586 0.4628E-03	0.9615 0.2612E-03	0.9619 0.4180E-03	0.9629 0.2731E-03	0.9643 0.7299E-03	0.9646 0.9110E-04
0.975	0.9704 0.1887E-02	0.9623 0.5899E-03	0.9677 0.1051E-02	0.9675 0.2072E-03	0.9689 0.6973E-03	0.9696 0.1234E-02	0.9696 0.1538E-02	0.9689 0.1760E-02
0.990	1.016 0.4894E-02	0.9747 0.1128E-02	0.9730 0.4941E-03	0.9726 0.1992E-02	0.9761 0.1250E-02	0.9738 0.1657E-02	0.9761 0.1291E-02	0.9730 0.2730E-02
MEAN OF REGRESSION ON AVERAGES		0.9411 0.2344E-02	-0.996 1.853		367.8 286.1	-0.1474E+05 0.1453E+05	-6170. 6370.	
STD DEV OF REGRESSION		0.5119E-02 0.8870E-03	2.923 0.3187		460.7 34.12	0.2261E+05 1240.	0.1068E+05 466.6	
REGRESSION ON VARIANCE		0.8146E-01 0.7360	11.39 23.36		-146.5 305.1	933.3 3102.	-2028. 6462.	

ESTIMATOR: ***rho(.0920) of SupData L Laplace AB r.v.s, $\mu=0.8$, $\sigma=.1$ Using moment estimator

Figure 43. Summary Statistics, L-Laplace samples. Moment Estimator.

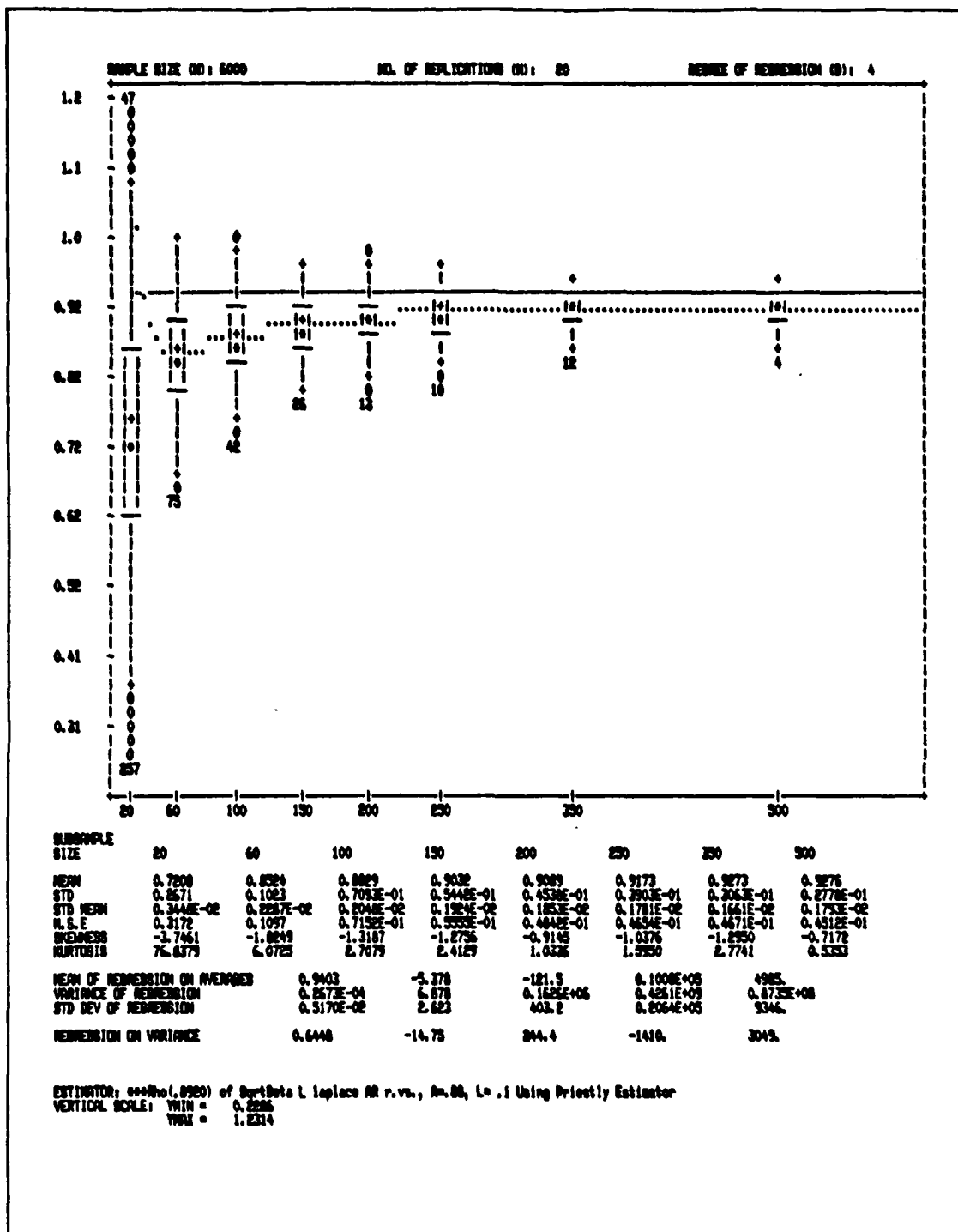


Figure 44. Individual Plot, L-Laplace samples. Priestley Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	80	80	100	130	200	230	230	300
MEAN	0.7217 0.647E-03	0.8539 0.1271E-02	0.8842 0.7063E-03	0.9018 0.1162E-02	0.9285 0.3401E-03	0.9139 0.6977E-03	0.9231 0.6936E-02	0.9254 0.1149E-02
STD	0.2914 0.2613E-01	0.1885 0.1143E-02	0.7090E-01 0.1239E-02	0.9401E-01 0.6323E-03	0.4723E-01 0.9123E-03	0.4089E-01 0.8023E-03	0.3093E-01 0.1192E-02	0.8833E-01 0.1073E-02
N.B.E	0.2280 0.2230E-01	0.1093 0.1459E-02	0.7134E-01 0.1284E-02	0.3940E-01 0.4823E-03	0.3091E-01 0.7304E-03	0.4689E-01 0.4442E-03	0.4038E-01 0.7007E-03	0.4381E-01 0.7071E-03
OVERPERS	-0.6138 1.663	-1.863 0.1383	-1.539 0.2332	-1.322 0.3063E-01	-1.240 0.8549	-1.241 0.1322	-1.086 0.1060	-0.9333 0.8260
MULTIPLIER	196.2 128.2	7.025 1.471	4.647 1.907	2.027 0.3195	2.047 1.900	2.963 1.462	2.489 0.3136	1.302 0.7991
SEL. COV.	0.2030E-02 0.4032E-02	0.1093E-01 0.1194E-01	-0.1873E-02 0.1382E-01	-0.2973E-02 0.1742E-01	0.8833E-02 0.3733E-01	-0.3030E-01 0.3030E-01	-0.4783E-01 0.2040E-01	0.4483E-01 0.3462E-01
QUANTILES								
0.010	-0.4129E-01 0.2139E-02	0.4885 0.7678E-02	0.5463 0.7884E-02	0.7043 0.8184E-02	0.7616 0.7372E-02	0.7916 0.7884E-02	0.8170 0.2284E-02	0.8310 0.9778E-02
0.025	0.1196 0.1938E-02	0.9777 0.9323E-03	0.7074 0.4854E-02	0.7674 0.6452E-02	0.7910 0.7674E-02	0.8169 0.3813E-02	0.8433 0.5127E-02	0.8533 0.7983E-02
0.050	0.2861 0.1339E-02	0.6630 0.4474E-02	0.7331 0.3842E-02	0.8000 0.6298E-02	0.8168 0.3272E-02	0.8429 0.2543E-03	0.8632 0.4047E-02	0.8709 0.3001E-02
0.100	0.4414 0.1873E-03	0.7382 0.1866E-02	0.7936 0.2643E-02	0.8302 0.3739E-03	0.8480 0.4289E-03	0.8635 0.1330E-02	0.8805 0.3711E-02	0.8890 0.2417E-02
0.250	0.6257 0.2633E-02	0.8106 0.1412E-02	0.8525 0.1678E-02	0.8754 0.1839E-02	0.8848 0.9761E-03	0.8926 0.9210E-03	0.9057 0.3607E-02	0.9091 0.1217E-02
0.500	0.7624 0.3942E-03	0.8742 0.1238E-02	0.8981 0.5332E-03	0.9117 0.1923E-02	0.9139 0.9221E-03	0.9228 0.1251E-02	0.9283 0.2423E-02	0.9291 0.1433E-02
0.750	0.8683 0.7000E-03	0.9211 0.1610E-02	0.9330 0.1517E-02	0.9401 0.5784E-03	0.9424 0.2502E-03	0.9448 0.9302E-03	0.9472 0.1049E-02	0.9488 0.1364E-02
0.900	0.9423 0.7000E-03	0.9532 0.1698E-02	0.9561 0.3453E-03	0.9582 0.7918E-03	0.9599 0.6151E-03	0.9593 0.5722E-03	0.9603 0.4137E-03	0.9577 0.4553E-03
0.950	0.9633 0.1783E-02	0.9743 0.1073E-02	0.9685 0.7223E-03	0.9699 0.5344E-03	0.9689 0.1300E-02	0.9682 0.1007E-02	0.9665 0.6197E-03	0.9639 0.2021E-02
0.975	1.036 0.9100E-03	0.9899 0.1099E-02	0.9793 0.1910E-02	0.9765 0.8300E-03	0.9762 0.5872E-03	0.9728 0.3748E-03	0.9717 0.8038E-03	0.9710 0.1484E-02
0.990	1.157 0.1180E-01	1.007 0.2356E-02	0.9951 0.3063E-02	0.9871 0.1602E-02	0.9857 0.6744E-03	0.9789 0.1322E-02	0.9736 0.1397E-02	0.9770 0.1974E-02
MEAN OF REDEMPTION ON AVERAGES		0.9268 0.1897E-02	-5.219 0.2228	-46.85 37.48	4882. 2397.		8439. 1364.	
STD DEV OF REDEMPTION		0.9238E-02 0.4356E-03	2.672 0.3232	408.1 48.94	0.8082E+05 2338.		9419. 1021.	
REDEMPTION ON VARIANCE		0.3705 0.1506	-0.2305 7.271	14.89 117.4	-31.86 726.9		408.7 1433.	
ESTIMATOR: ccc@cc(0.9920) of SpRbeta L Laplace RE r.v., θ , θ , $L = 1$ Using Priestly Estimator								

Figure 45. Summary Statistics, L-Laplace samples. Priestley Estimator.

by Denby and Martin with their estimators [Ref. 9, p.141]. Figures 48 and 49 have the results with the scaling, and Figures 46 and 47 have no additional scaling. There is not much difference in the behavior of these two different approaches. The extreme bias of the robust regression is present in both cases, for the non-Normal BELAR(1) sample distribution being used here.

C. NON-NORMALLY DISTRIBUTED SAMPLES, UNCORRELATED

This section presents results for the case of the BELAR(1) process, with values of α chosen to produce a very small correlation, on the order of 0.05. In these cases, the problems associated with the random number generators previously discussed appear again, since the values of l we are interested in range from three down to 0.1. Thus, the cases for $l = 1$, and $l = 0.1$ produced underflow errors and invalid results. Results are available for the cases where $l = 3$ and $l = 0.4$. Figure 50 is a color combined estimator plot, with all four estimators, in the case of uncorrelated BELAR(1) samples. Here, the moment estimator seems to show the least degree of small-sample bias, but the Cressie estimator has the best asymptotic performance. Figures 51 through 54 are the super-replications summary statistics for each of the four estimator under conditions where $l = 3$. This picture is similar to that of the Normally distributed, uncorrelated samples. From the regression asymptotes, the Cressie estimator appears to show the best asymptotic behavior, although all estimators seem to be over-estimating the true value, indicating there is more correlation in the samples than is actually present. This occurs for all sub-sample sizes.

Figures 55 through 59 show the results for the uncorrelated BELAR(1) process, with $l = 0.4$. The results are similar to those above, and the Normal uncorrelated case. All of these estimators will tend to indicate a slight degree of correlation, even if the samples are completely independent, just due to the nature of performing calculations on the sample streams. It is very unlikely that they will indicate a zero correlation; something like 0.5 to 0.1 is more likely to be the case.

This concludes the presentation of simulation results on lag-1 serial correlation using SIMTBED. For the negatively correlated case, results similar to the positively correlated case are expected, including the random number generation difficulties.

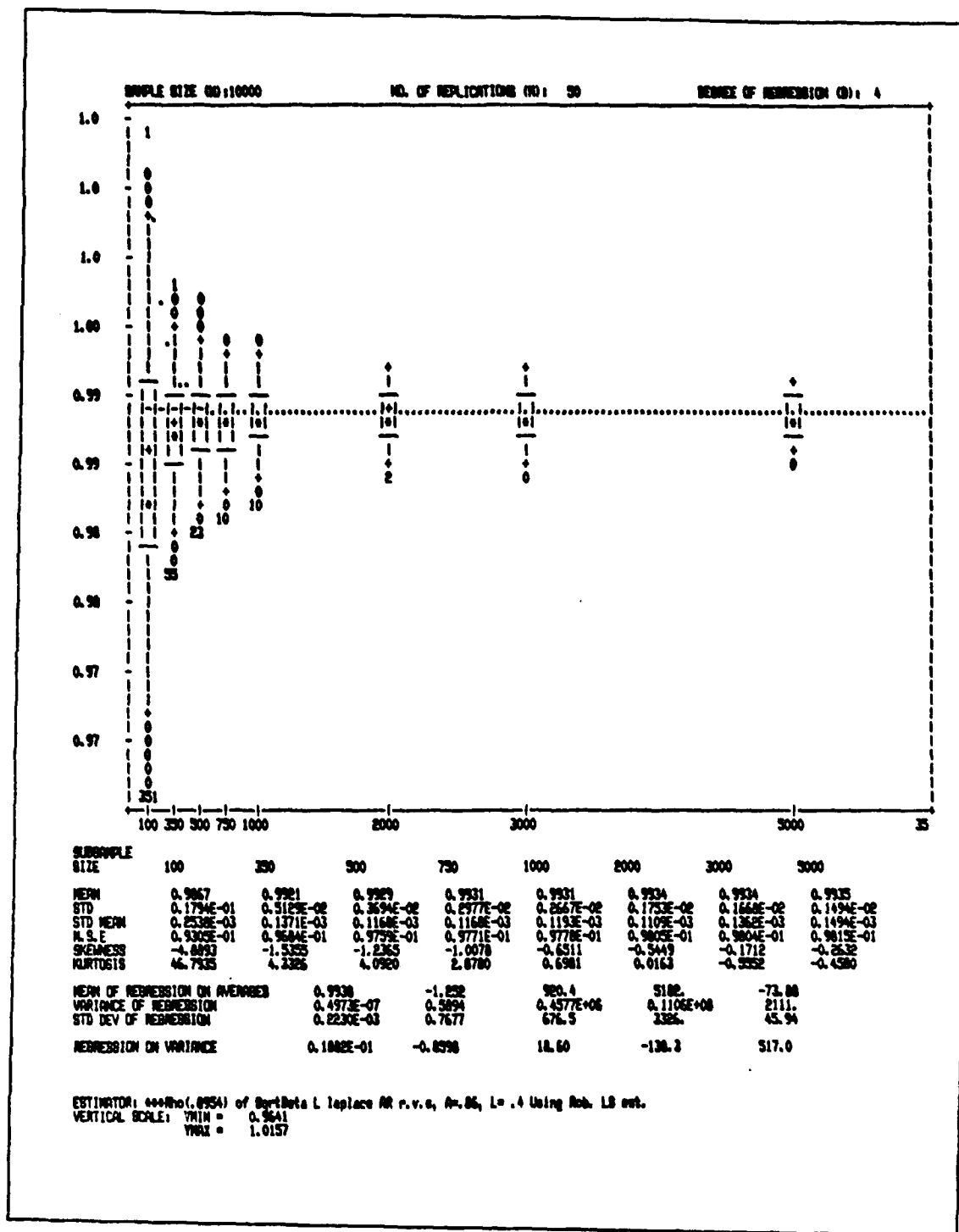


Figure 46. Individual Plot, No Additional Scaling. Robust Least Squares.

SUMMARY STATISTICS (MEAN/STD) 3 SUPER-REPLICATIONS								
SUBSAMPLE SIZE	100	200	300	750	1000	2000	3000	
MEAN	0.9899 0.1650E-03	0.9899 0.7290E-04	0.9897 0.8790E-04	0.9899 0.9610E-04	0.9899 0.5040E-04	0.9894 0.2300E-04	0.9894 0.7810E-04	0.9894 0.6120E-04
STD	0.1700E-01 0.1800E-03	0.4670E-02 0.1200E-03	0.2830E-02 0.9440E-04	0.8990E-02 0.4507E-04	0.8990E-02 0.7800E-04	0.1940E-02 0.6940E-04	0.1390E-02 0.6310E-04	0.1330E-02 0.8820E-04
A.B.E	0.9899E-01 0.1270E-03	0.9899E-01 0.6890E-04	0.9740E-01 0.8510E-04	0.9730E-01 0.9630E-04	0.9700E-01 0.9940E-04	0.9770E-01 0.2940E-04	0.9800E-01 0.7880E-04	0.9800E-01 0.6180E-04
MEAN/STD	-1.627 0.1450	-1.512 0.3050E-01	-1.267 0.2762	-0.8822 0.7770E-01	-0.6105 0.2120E-01	-0.3825 0.1160	-0.2914 0.2800E-01	-0.8380E-01 0.1111
NUMTOSIS	40.14 2.763	4.963 0.4183	2.994 0.210	1.887 0.4936	0.8897 0.2142	0.1113 0.1880	-0.2778 0.1943	-0.6880 0.1275
SEL. COV.	0.9677E-02 0.9400E-02	-0.1510E-01 0.1270E-01	0.6140E-02 0.2900E-01	-0.4590E-02 0.4020E-01	-0.8771E-01 0.1120E-01	0.2740E-02 0.2031E-01	0.2370E-01 0.2770E-01	0.8540E-01 0.6780E-01
QUANTILES								
0.010	0.9120 0.1990E-02	0.9760 0.9181E-03	0.9803 0.1474E-02	0.9847 0.1730E-03	0.9899 0.4927E-03	0.9881 0.4441E-03	0.9895 0.3217E-04	0.9900 0.1530E-03
0.025	0.9430 0.9170E-03	0.9804 0.7309E-03	0.9840 0.3533E-03	0.9866 0.2317E-03	0.9871 0.2640E-03	0.9893 0.1620E-03	0.9899 0.9760E-04	0.9905 0.1830E-03
0.050	0.9575 0.6807E-03	0.9832 0.3730E-03	0.9860 0.2227E-03	0.9878 0.1580E-03	0.9884 0.1860E-03	0.9899 0.2380E-03	0.9906 0.2430E-04	0.9909 0.1228E-03
0.100	0.9708 0.2390E-03	0.9862 0.1390E-03	0.9881 0.1609E-03	0.9892 0.9430E-04	0.9896 0.3930E-04	0.9909 0.1314E-03	0.9913 0.1080E-03	0.9913 0.5190E-04
0.250	0.9835 0.1150E-03	0.9900 0.1540E-03	0.9907 0.1430E-03	0.9912 0.1240E-03	0.9916 0.4081E-04	0.9923 0.3140E-04	0.9924 0.1241E-03	0.9928 0.1340E-03
0.500	0.9914 0.1220E-03	0.9930 0.3630E-04	0.9932 0.3560E-04	0.9933 0.7720E-04	0.9935 0.2734E-04	0.9936 0.1630E-03	0.9934 0.7340E-04	0.9935 0.6340E-04
0.750	0.9963 0.1170E-03	0.9935 0.5857E-04	0.9954 0.5840E-04	0.9950 0.9900E-04	0.9950 0.1197E-03	0.9947 0.2580E-04	0.9946 0.1460E-03	0.9946 0.6570E-04
0.900	0.9985 0.3330E-04	0.9974 0.2540E-04	0.9970 0.4540E-04	0.9962 0.1150E-03	0.9962 0.1680E-03	0.9966 0.2860E-04	0.9963 0.1250E-03	0.9964 0.4617E-04
0.950	1.001 0.6237E-04	0.9984 0.6472E-04	0.9979 0.2290E-04	0.9970 0.1341E-03	0.9969 0.2137E-03	0.9961 0.4780E-04	0.9960 0.1280E-03	0.9959 0.1860E-04
0.975	1.003 0.2397E-03	0.9992 0.8354E-04	0.9985 0.3090E-04	0.9977 0.1190E-03	0.9974 0.2411E-03	0.9964 0.1231E-03	0.9963 0.2270E-03	0.9964 0.1490E-03
0.990	1.006 0.2190E-03	1.000 0.1711E-03	0.9996 0.8306E-04	0.9984 0.8284E-04	0.9980 0.2192E-03	0.9969 0.1787E-03	0.9970 0.6597E-04	0.9967 0.8119E-04
MEAN OF REGRESSION ON AVERAGES		0.9535 0.1340E-03	-0.3595 0.4863	16.27 486.2	266.7 2357.	-6.140 26.02		
STD DEV OF REGRESSION		0.2439E-03 0.1487E-04	0.7796 0.5370E-01	682.7 29.31	2344. 166.9	46.12 2.136		
REGRESSION ON VARIANCE		0.3101E-01 0.6300E-02	-2.304 0.7510	74.75 29.24	-988.6 447.4	4823. 2237.		
ESTIMATOR: ***rho(.8954) of Bivariate L Laplace RR r.v.s, R=86, L=.4 Using Rob. LS est.								
*** WIDEST Y VALUES FOUND: YMIN=0.6740 - YMAX=1.035 *** BRTS ***								
*** THIS WAS A RESTART RUN. NBR START/END= 1 3 ***								

Figure 47. Summary Stats, No Additional Scaling. Robust Least Squares.

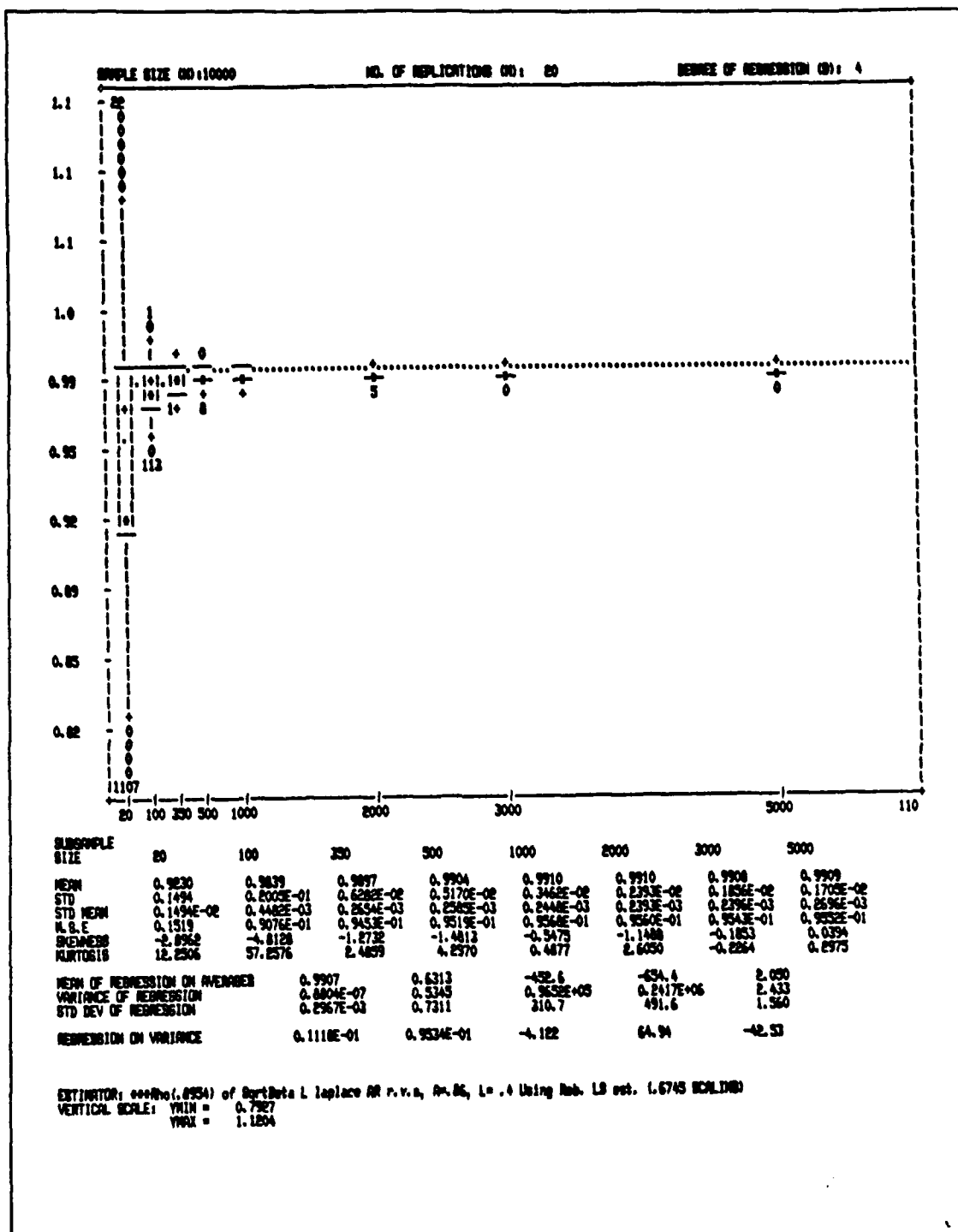


Figure 48. Individual Plot, Additional Scaling. Robust Least Squares.

SUMMARY STATISTICS (MEM/STD)								
2 SUPER-REPLICATIONS								
SAMPLE SIZE	50	100	250	500	1000	2000	3000	5000
MEM	0.9827 0.4792E-03	0.9838 0.8194E-04	0.9896 0.1863E-03	0.9903 0.7080E-04	0.9910 0.2762E-04	0.9908 0.1487E-03	0.9909 0.6399E-04	0.9909 0.1593E-03
STD	0.1308 0.4821E-03	0.8861E-01 0.4258E-03	0.6598E-02 0.2305E-03	0.3008E-02 0.1291E-03	0.2431E-02 0.1210E-03	0.2215E-02 0.4312E-04	0.1883E-02 0.2772E-04	0.1893E-02 0.4293E-04
N.S.E	0.1385 0.4983E-03	0.9077E-01 0.2270E-04	0.9448E-01 0.1488E-03	0.9502E-01 0.7701E-04	0.9508E-01 0.4287E-04	0.9538E-01 0.1491E-03	0.9538E-01 0.4287E-04	0.9538E-01 0.1583E-03
SPREADS	-2.141 0.1710	-4.202 0.4029	-1.639 0.4471	-1.197 0.1691	-1.083 0.8813	-0.7389 0.8674	-0.1910 0.5293E-04	0.7163E-02 0.1704
NUMTOSIS	15.80 2.458	46.05 2.907	6.138 2.629	2.087 0.6380	1.985 1.195	1.217 0.6688	-0.1279 0.6882	-0.2810 0.3294
REL. COV.	-0.3764E-02 0.4380E-02	0.1981E-01 0.2532E-01	-0.6930E-01 0.2861E-01	0.2990E-01 0.2543E-01	0.2818E-01 0.1212E-01	-0.2814E-01 0.7548E-01	-0.6333E-02 0.2876E-01	-0.1121 0.6643E-04
SUBTILES								
0.010	0.8428 0.6944E-02	0.9085 0.1703E-02	0.9683 0.1632E-02	0.9723 0.2434E-02	0.9784 0.1923E-02	0.9827 0.1073E-02	0.9861 0.5083E-03	0.9872 0.4723E-03
0.025	0.8404 0.6380E-02	0.9315 0.1765E-02	0.9748 0.8212E-03	0.9790 0.6599E-03	0.9809 0.7286E-03	0.9850 0.3113E-03	0.9864 0.2762E-03	0.9878 0.4602E-03
0.050	0.8160 0.4872E-02	0.9483 0.1537E-02	0.9779 0.4585E-03	0.9817 0.2361E-03	0.9849 0.2008E-03	0.9867 0.2088E-03	0.9875 0.1113E-03	0.9884 0.5946E-04
0.100	0.7784 0.8250E-03	0.9630 0.4850E-03	0.9810 0.4044E-03	0.9840 0.1565E-03	0.9864 0.8034E-03	0.9878 0.2591E-03	0.9888 0.1384E-03	0.9888 0.8376E-04
0.250	0.9144 0.2536E-03	0.9785 0.2532E-03	0.9863 0.3387E-03	0.9878 0.5709E-04	0.9892 0.2570E-03	0.9894 0.3050E-03	0.9896 0.8063E-04	0.9896 0.2506E-03
0.500	0.9772 0.4866E-03	0.9891 0.9878E-04	0.9908 0.2413E-03	0.9909 0.1211E-03	0.9914 0.2169E-04	0.9910 0.1688E-03	0.9910 0.7781E-04	0.9911 0.1783E-03
0.750	0.9973 0.1831E-03	0.9954 0.8916E-04	0.9941 0.2200E-03	0.9937 0.1049E-03	0.9935 0.1038E-03	0.9984 0.1531E-03	0.9982 0.5133E-04	0.9981 0.2218E-03
0.900	1.009 0.2773E-03	0.9995 0.2652E-04	0.9964 0.1387E-03	0.9960 0.1747E-03	0.9990 0.2297E-03	0.9936 0.8313E-04	0.9933 0.8053E-03	0.9932 0.1249E-03
0.950	1.020 0.7052E-03	1.002 0.1168E-03	0.9979 0.1279E-03	0.9972 0.8130E-04	0.9998 0.2874E-03	0.9941 0.2523E-03	0.9939 0.2638E-03	0.9941 0.1154E-03
0.975	1.034 0.9061E-03	1.005 0.3372E-03	0.9988 0.2101E-03	0.9979 0.7842E-04	0.9963 0.2899E-03	0.9947 0.1950E-03	0.9947 0.1273E-03	0.9945 0.1783E-03
0.990	1.058 0.1577E-02	1.009 0.3477E-03	0.9998 0.2522E-03	0.9988 0.2936E-03	0.9969 0.2742E-03	0.9935 0.1261E-03	0.9933 0.1486E-03	0.9946 0.1838E-03
MEAN OF REGRESSION ON AVERAGES		0.9908 0.5404E-04	0.4012 0.1293	-370.4 41.18	-329.8 62.35	1.639 0.1972		
STD DEV OF REGRESSION		0.2717E-03 0.1253E-04	0.6629 0.3528E-01	291.5 9.638	457.7 11.99	1.489 0.3574E-01		
REGRESSION ON VARIANCE		0.1871E-01 0.6711E-02	-0.5937 0.7932	12.48 21.18	-65.32 192.1	338.9 302.9		
ESTIMATOR: ***Ho(0.954) of Sp+Beta L Laplace RR r.v.s, A=.86, L=.4 Using Rob. LS est. (.6745 SCALING)								
*** WIDEST Y VALUES FOUND: YMIN=-1.863 - YMAX= 2.461 *** ENTS ***								
*** THIS WAS A RESTART RUN. REA START/END= 1 2 *** ENTS ***								

Figure 49. Summary Stats, Additional Scaling. Robust Least Squares.

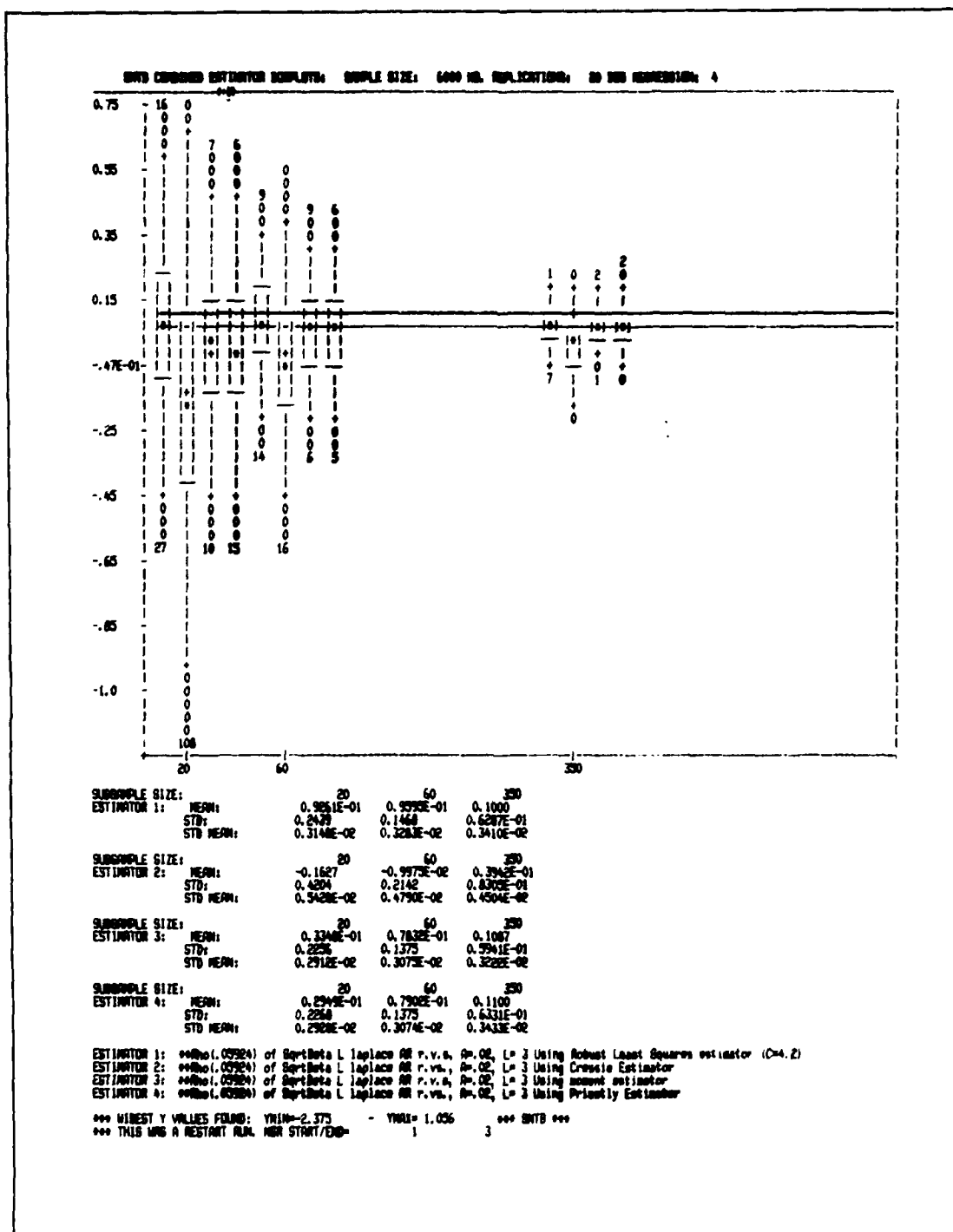


Figure 50. Combined Plot, BELAR(1) Process. L = 3. Rho = 0.05924.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	60	100	150	200	250	300	300
MEAN	0.901E-01 0.237E-02	0.903E-01 0.157E-02	0.903E-01 0.181E-02	0.903E-01 0.216E-02	0.903E-01 0.232E-02	0.9017 0.257E-03	0.901E-01 0.291E-03	0.901E-01 0.179E-02
STD	0.040 0.160E-02	0.106 0.201E-02	0.112 0.104E-02	0.903E-01 0.714E-03	0.709E-01 0.477E-03	0.709E-01 0.212E-02	0.604E-01 0.122E-02	0.407E-01 0.112E-02
N.S.E	0.042 0.107E-02	0.102 0.174E-02	0.109 0.108E-02	0.109 0.103E-02	0.903E-01 0.903E-03	0.903E-01 0.903E-02	0.709E-01 0.709E-02	0.612E-01 0.202E-03
BIASNESS	-0.002E-01 0.103E-01	-0.007E-01 0.471E-01	-0.001E-01 0.342E-01	0.046E-01 0.103E-01	0.143 0.921E-02	-0.007E-01 0.903E-01	-0.009 0.157E	-0.104E-01 0.442E-01
KURTOSIS	0.304E-01 0.126E-01	0.127 0.254E-01	0.145 0.143E-01	-0.115 0.103E-01	-0.173 0.173	0.109 0.601E-01	0.149 0.692	0.729E-01 0.253
SEA. COE.	0.477E-01 0.174E-01	-0.103E-01 0.103E-01	-0.094E-01 0.193E-01	0.121E-01 0.121E-01	-0.166E-01 0.122E-01	-0.121E-01 0.122E-01	-0.092E-01 0.292E-01	-0.092E-01 0.292E-01
BOOTLEES								
0.010	-0.463 0.709E-02	-0.2301 0.124E-01	-0.179 0.231E-02	-0.129 0.254E-02	-0.723E-01 0.477E-02	-0.711E-01 0.116E-01	-0.341E-01 0.104E-01	-0.217E-01 0.452E-02
0.025	-0.3879 0.437E-02	-0.1879 0.742E-02	-0.1262 0.244E-02	-0.823E-01 0.231E-02	-0.497E-01 0.231E-02	-0.401E-01 0.349E-03	-0.214E-01 0.108E-01	0.230E-02 0.474E-02
0.050	-0.3093 0.453E-02	-0.1486 0.731E-02	-0.909E-01 0.204E-02	-0.283E-01 0.234E-02	-0.299E-01 0.286E-02	-0.130E-01 0.279E-02	-0.400E-02 0.604E-02	0.200E-01 0.494E-02
0.100	-0.2202 0.453E-02	-0.873E-01 0.707E-02	-0.426E-01 0.441E-02	-0.178E-01 0.297E-02	-0.302E-02 0.403E-02	0.129E-01 0.273E-02	0.277E-01 0.134E-02	0.265E-01 0.392E-02
0.250	-0.719E-01 0.442E-02	0.121E-02 0.224E-02	0.210E-01 0.163E-02	0.246E-01 0.134E-02	0.407E-01 0.346E-02	0.393E-01 0.187E-02	0.396E-01 0.230E-02	0.679E-01 0.246E-02
0.500	0.909E-01 0.311E-02	0.906E-01 0.192E-02	0.904E-01 0.137E-02	0.904E-01 0.182E-02	0.901E-01 0.287E-02	0.102 0.149E-02	0.101 0.236E-02	0.107 0.231E-02
0.750	0.2581 0.1461E-02	0.1929 0.140E-02	0.1701 0.199E-02	0.1625 0.349E-02	0.1408 0.189E-02	0.1308 0.270E-02	0.1391 0.193E-02	0.1308 0.282E-03
0.900	0.4057 0.639E-03	0.2793 0.126E-02	0.2363 0.232E-02	0.2203 0.276E-02	0.1991 0.220E-02	0.1928 0.308E-02	0.1739 0.210E-02	0.1625 0.185E-02
0.950	0.4099 0.222E-02	0.3385 0.233E-02	0.2747 0.310E-02	0.234 0.321E-02	0.2291 0.364E-02	0.2137 0.770E-02	0.1939 0.576E-02	0.1894 0.258E-02
0.975	0.3649 0.263E-02	0.3794 0.543E-02	0.3112 0.303E-02	0.2819 0.490E-02	0.2511 0.493E-02	0.2259 0.252E-02	0.2168 0.532E-02	0.1931 0.406E-02
0.990	0.6591 0.642E-02	0.4387 0.696E-02	0.3517 0.682E-02	0.3096 0.226E-02	0.2911 0.110E-03	0.2525 0.231E-02	0.2369 0.932E-02	0.2180 0.208E-02
MEAN OF REGRESSION ON AVERAGES		0.933E-01 0.803E-02	0.3915 4.112	-175.7 501.7		0.1114E+05 0.283E+05	5389. 0.127E+05	
STD DEV OF REGRESSION		0.887E-02 0.921E-03	4.533 0.3710	675.2 40.86		0.3417E+05 1751.	0.1536E+05 745.2	
REGRESSION ON VARIANCE		0.4734 0.2610	31.42 16.21	-443.8 229.3		2390. 1850.	-3829. 2344.	

ESTIMATION: 0000(L.30924) of Sphero L. Laplace AN r.v.s. $\alpha=0.2$, $L=3$ Using Robust Least Squares estimator (D-4.2)

Figure 51. Summary Statistics, L-Laplace Samples. Robust Least Squares.

SUMMARY STATISTICS (MEAN/STD)				3 REPLICATIONS				
SUBSAMPLE SIZE	20	50	100	150	200	250	300	350
MEAN	-0.1274 0.433E-02	-0.1004E-01 0.1072E-02	-0.1057E-01 0.233E-02	-0.0829E-01 0.1444E-02	-0.2708E-01 0.1963E-02	-0.2772E-01 0.1462E-02	-0.2428E-01 0.2023E-02	-0.2145E-01 0.2145E-02
STD	0.4199 0.4793E-02	0.2112 0.238E-02	0.1292 0.707E-03	0.1277 0.166E-02	0.1136 0.213E-02	0.2357E-01 0.2357E-02	0.2323E-01 0.2323E-02	0.2792E-01 0.1172E-02
N.B.E	0.4638 0.398E-02	0.2294 0.221E-02	0.1644 0.642E-03	0.1219 0.723E-03	0.1124 0.227E-02	0.1942E-03 0.723E-03	0.2382E-01 0.2382E-02	0.2382E-01 0.1343E-02
WEAWEBO	-0.6219 0.243E-01	-0.2240 0.223E-01	-0.2405 0.423E-01	-0.2418 0.607E-02	-0.2243 0.242E-01	-0.2077E-01 0.217E-01	-0.2077E-01 0.192E-01	-0.2382E-01 0.432E-01
PLURTOBIS	0.7029 0.400E-01	0.2643E-01 0.263E-01	0.1179 0.128E-01	0.1485 0.607E-01	0.1098 0.609E-01	-0.1029 0.224E-01	-0.1029 0.223E-01	-0.2002E-01 0.2002E-02
MEAN COR.	-0.1274E-01 0.433E-02	-0.1004E-02 0.1072E-02	-0.1057E-02 0.233E-02	-0.0829E-02 0.1444E-02	-0.2708E-02 0.1963E-02	-0.2772E-02 0.1462E-02	-0.2428E-02 0.2023E-02	-0.2145E-02 0.2145E-02
QUANTILES								
0.010	-1.305 0.303E-01	-0.3204 0.304E-02	-0.4004 0.143E-01	-0.2531 0.112E-01	-0.2457 0.103E-01	-0.2019 0.136E-01	-0.1207 0.211E-02	-0.1021 0.777E-02
0.025	-1.099 0.240E-01	-0.4346 0.116E-01	-0.2773 0.504E-02	-0.2269 0.150E-02	-0.2041 0.100E-01	-0.1267 0.438E-02	-0.1199 0.497E-02	-0.7649E-01 0.612E-02
0.050	-0.8978 0.172E-01	-0.2787 0.721E-02	-0.2519 0.634E-02	-0.1937 0.156E-02	-0.1608 0.252E-02	-0.1229 0.304E-02	-0.1024 0.723E-02	-0.6032E-01 0.653E-02
0.100	-0.6981 0.127E-01	-0.2090 0.603E-02	-0.1913 0.603E-02	-0.1413 0.376E-02	-0.1059 0.221E-02	-0.0302E-01 0.450E-02	-0.0302E-01 0.704E-02	-0.2717E-01 0.435E-02
0.250	-0.4021 0.303E-02	-0.1476 0.463E-02	-0.0302E-01 0.270E-02	-0.3443E-01 0.157E-02	-0.2402E-01 0.223E-02	-0.0994E-01 0.164E-02	-0.1351E-01 0.497E-02	-0.2472E-02 0.262E-02
0.500	-0.1117 0.222E-02	0.2363E-03 0.172E-02	0.2540E-01 0.274E-02	0.2023E-01 0.2610E-02	0.4002E-01 0.387E-02	0.4032E-01 0.211E-02	0.4530E-01 0.222E-02	0.3517E-01 0.485E-02
0.750	0.1432 0.322E-02	0.1431 0.917E-03	0.1314 0.347E-02	0.1117 0.267E-02	0.1218 0.433E-02	0.1085 0.131E-02	0.1022 0.227E-02	0.9911E-01 0.561E-02
0.900	0.2349 0.294E-02	0.2538 0.234E-02	0.2140 0.289E-02	0.1881 0.280E-03	0.1817 0.184E-02	0.1706 0.224E-02	0.1483 0.451E-02	0.1310 0.492E-02
0.950	0.4310 0.226E-02	0.2153 0.643E-02	0.2522 0.187E-02	0.2281 0.489E-02	0.2203 0.425E-02	0.2045 0.448E-02	0.1732 0.812E-02	0.1393 0.572E-02
0.975	0.3099 0.347E-02	0.2704 0.513E-02	0.2072 0.732E-02	0.2519 0.727E-03	0.2302 0.262E-03	0.2213 0.366E-02	0.2080 0.304E-02	0.1892 0.277E-02
0.990	0.5985 0.292E-02	0.4802 0.292E-02	0.2541 0.706E-02	0.2042 0.236E-02	0.2240 0.237E-02	0.2524 0.226E-02	0.2262 0.123E-01	0.2191 0.703E-02
MEAN OF REGRESSION ON AVERAGES			0.647E-01 0.104E-01	-0.164 3.981	392.4 440.2	-0.2284E+05 0.187E+05	-0.1251E+05 7893.	
STD DEV OF REGRESSION			0.1102E-01 0.246E-03	6.490 0.3601	979.0 44.84	0.4929E+05 1965.	0.2217E+05 838.8	
REGRESSION ON VARIANCE			-0.2149 2.539	109.4 108.0	-1574. 1581.	9436. 9475.	-0.1906E+05 0.1537E+05	

EXTINTOR: 0000(0.00924) of SupData L Laplace RR r.v.s., R=02, L=3 Using Cressie Estimator

Figure 52. Summary Statistics, L-Laplace Samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	20	60	100	150	200	250	300	350
MEAN	0.771E-01 0.716E-01	0.770E-01 0.716E-01	0.770E-01 0.716E-01	0.769E-01 0.716E-01	0.769E-01 0.716E-01	0.769E-01 0.716E-01	0.769E-01 0.716E-01	0.769E-01 0.716E-01
STD	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02
N.S.E	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02	0.127E-02 0.127E-02
MEAN/STD	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01	0.490E-02 0.170E-01
HARTMAN	-0.1919 0.215E-01	-0.229E-01 0.480E-01	-0.121E-01 0.733E-01	0.182E 0.733E-01	0.1140 0.777E-01	0.1081 0.777E-01	0.1081 0.777E-01	0.1081 0.777E-01
REL. COV.	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02	-0.1919E-01 0.673E-02
QUANTILES								
0.010	-0.4770 0.7174E-02	-0.2254 0.638E-02	-0.1379 0.250E-02	-0.1109 0.483E-02	-0.7421E-01 0.7111E-02	-0.672E-01 0.689E-02	-0.448E-01 0.67E-02	-0.132E-01 0.354E-02
0.025	-0.3988 0.5407E-02	-0.1917 0.206E-02	-0.1072 0.4891E-02	-0.709E-01 0.484E-02	-0.477E-01 0.353E-02	-0.338E-01 0.257E-02	-0.189E-01 0.253E-02	-0.461E-02 0.282E-02
0.050	-0.3389 0.629E-02	-0.1481 0.166E-02	-0.814E-01 0.414E-02	-0.433E-01 0.372E-02	-0.289E-01 0.251E-02	-0.140E-01 0.217E-02	0.251E-02 0.250E-02	0.375E-01 0.375E-02
0.100	-0.2393 0.190E-02	-0.264E-01 0.8821E-03	-0.446E-01 0.384E-02	-0.116E-01 0.230E-02	0.203E-02 0.203E-02	0.137E-01 0.200E-02	0.314E-01 0.173E-02	0.408E-01 0.264E-02
0.250	-0.1230 0.132E-02	-0.119E-01 0.489E-02	0.136E-01 0.208E-02	0.373E-01 0.123E-02	0.4891E-01 0.214E-02	0.251E-01 0.194E-02	0.647E-01 0.275E-02	0.693E-01 0.334E-02
0.500	0.330E-01 0.160E-02	0.811E-01 0.320E-02	0.929E-01 0.156E-02	0.964E-01 0.247E-02	0.967E-01 0.183E-02	0.103E 0.199E-02	0.104E 0.281E-02	0.101E 0.248E-02
0.750	0.1917 0.180E-02	0.170E 0.331E-02	0.1670 0.3211E-02	0.1549 0.166E-02	0.1474 0.209E-02	0.1489 0.1914E-02	0.144E 0.257E-02	0.1344 0.6741E-03
0.900	0.3878 0.129E-02	0.250E 0.112E-02	0.2293 0.152E-02	0.208E 0.204E-02	0.1981 0.318E-02	0.1875 0.118E-02	0.1830 0.267E-02	0.1649 0.310E-02
0.950	0.4032 0.184E-02	0.2990 0.4607E-02	0.2577 0.4961E-02	0.2429 0.126E-02	0.223E 0.290E-02	0.2138 0.782E-03	0.2057 0.937E-03	0.1889 0.299E-02
0.975	0.4732 0.3947E-02	0.3393 0.500E-02	0.3049 0.937E-02	0.2713 0.1417E-02	0.2429 0.299E-02	0.2405 0.1187E-02	0.2297 0.2610E-02	0.2028 0.325E-02
0.990	0.5484 0.199E-02	0.3921 0.849E-02	0.3991 0.1341E-01	0.3138 0.108E-01	0.2745 0.423E-02	0.2528 0.428E-02	0.2533 0.446E-02	0.2245 0.816E-02
MEAN OF REGRESSION ON AVERAGES		0.1081 0.9141E-02	-0.159 4.711	194.7 682.6	-0.1014E+05 0.338E+05	-3087. 0.1474E+05		
STD DEV OF REGRESSION		0.896E-02 0.136E-02	4.804 0.6471	741.8 71.83	0.3771E+05 85.36	0.1701E+05 992.3		
REGRESSION ON VARIANCE		2.458 0.9637	-49.18 29.21	669.6 563.7	-3863. 3364.	7718. 6714.		
ESTIMATOR: $\hat{\theta} = \frac{1}{n} \sum_{i=1}^n x_i^2$ of $\text{Spirito L. Laplace}$ for $\mu = 0.02$, $\sigma = 0.02$, $L = 3$ Using moment estimator								

Figure 53. Summary Statistics, L-Laplace Samples. Moment Estimator.

SUMMARY STATISTICS (MEAN/STD)								
3 SUPER-REPLICATIONS								
SAMPLE SIZE	20	60	100	150	200	250	300	350
MEAN	0.3151E-01 0.1904E-02	0.8850E-01 0.1793E-02	0.9879E-01 0.1128E-02	0.9800E-01 0.1444E-02	0.9738E-01 0.2771E-02	0.1021 0.1988E-02	0.1030 0.2301E-02	0.1031 0.1648E-02
STD	0.8864 0.7034E-03	0.1265 0.4919E-03	0.1071 0.8740E-03	0.8799E-01 0.7678E-03	0.7680E-01 0.1093E-02	0.6783E-01 0.7668E-03	0.6089E-01 0.1362E-02	0.4778E-01 0.6300E-03
M.S.E	0.8861 0.9149E-03	0.1265 0.2278E-03	0.1123 0.8949E-03	0.9474E-01 0.9113E-03	0.8579E-01 0.2190E-02	0.8911E-01 0.1851E-02	0.7608E-01 0.2398E-02	0.6404E-01 0.1457E-02
BIAS	-0.3311E-01 0.1963E-01	0.3268E-01 0.1603E-01	-0.3629E-01 0.3848E-01	-0.1199E-01 0.2473E-01	-0.6388E-01 0.7807E-01	-0.1188E-01 0.3988E-01	0.8418E-01 0.1167	-0.1810 0.2344E-01
MURTOBIS	-0.8894 0.3321E-01	-0.4161E-01 0.6498E-01	-0.1111 0.4840E-01	-0.9447E-01 0.4077E-01	0.8447 0.1888	0.8843 0.2238	0.8398E-01 0.1764	0.8447E-02 0.2286
REL. COR.	0.6017E-02 0.1093E-01	0.8918E-01 0.7063E-02	0.3998E-02 0.8603E-02	-0.2977E-01 0.7853E-02	0.1118E-01 0.2382E-01	-0.3944E-01 0.3412E-01	0.3304E-01 0.1893E-01	-0.4389E-02 0.8118E-02
QUANTILES								
0.010	-0.4878 0.4078E-02	-0.2832 0.2232E-02	-0.1546 0.1118E-01	-0.1134 0.5724E-02	-0.9803E-01 0.8828E-02	-0.6403E-01 0.7884E-02	-0.3123E-01 0.7122E-02	-0.1813E-01 0.4619E-02
0.025	-0.4078 0.3381E-02	-0.1827 0.1728E-02	-0.1197 0.1040E-01	-0.8008E-01 0.6357E-02	-0.3647E-01 0.9417E-02	-0.3704E-01 0.3548E-02	-0.1686E-01 0.3577E-02	0.2107E-02 0.4023E-02
0.050	-0.3405 0.3694E-02	-0.1447 0.1373E-02	-0.8621E-01 0.2918E-02	-0.4807E-01 0.4058E-02	-0.2981E-01 0.4378E-02	-0.7230E-02 0.4458E-03	0.3188E-03 0.4618E-02	0.2230E-01 0.4892E-02
0.100	-0.2631 0.4543E-02	-0.9494E-01 0.6547E-03	-0.4806E-01 0.1962E-02	-0.1408E-01 0.4989E-02	0.1033E-02 0.3637E-02	0.1939E-01 0.2672E-02	0.2279E-01 0.2242E-02	0.3910E-01 0.2232E-02
0.250	-0.1292 0.2584E-02	-0.8891E-02 0.3806E-02	0.1941E-01 0.1110E-02	0.3433E-01 0.3377E-03	0.4847E-01 0.1406E-02	0.3613E-01 0.2498E-02	0.6577E-01 0.2265E-02	0.7118E-01 0.3724E-02
0.500	0.2289E-01 0.2441E-02	0.8357E-01 0.2540E-02	0.9497E-01 0.2703E-02	0.9698E-01 0.1163E-02	0.9710E-01 0.1610E-02	0.1017 0.1579E-02	0.1053 0.2906E-02	0.1046 0.3451E-02
0.750	0.1896 0.5647E-03	0.1737 0.2161E-02	0.1637 0.1194E-02	0.1569 0.2791E-02	0.1474 0.4890E-02	0.1476 0.2923E-02	0.1449 0.2813E-02	0.1358 0.9632E-03
0.900	0.3236 0.1356E-02	0.2580 0.3873E-03	0.2293 0.1308E-02	0.2061 0.2623E-02	0.1964 0.6438E-02	0.1884 0.2388E-02	0.1816 0.4930E-02	0.1620 0.1163E-02
0.950	0.4021 0.4153E-02	0.3047 0.1352E-02	0.2668 0.2313E-02	0.2375 0.2206E-02	0.2234 0.4899E-02	0.2119 0.3928E-02	0.2010 0.3548E-02	0.1823 0.3112E-02
0.975	0.4707 0.4060E-02	0.3536 0.1082E-02	0.3006 0.6447E-02	0.2672 0.1954E-02	0.2518 0.3568E-02	0.2394 0.3299E-02	0.2261 0.5480E-02	0.1931 0.3087E-02
0.990	0.5312 0.5996E-02	0.4030 0.7716E-02	0.3347 0.5153E-02	0.2980 0.1341E-02	0.2734 0.9227E-02	0.2511 0.7766E-02	0.2345 0.1084E-01	0.2138 0.7799E-02
MEAN OF REGRESSION ON AVERAGES		0.1098 0.4056E-02	-2.630 2.320	177.0 376.2	-7902 0.1828E+05	-3345 8090.		
STD DEV OF REGRESSION		0.9668E-02 0.1014E-02	4.953 0.5715	728.6 84.45	0.2692E+05 4068.	0.1657E+05 1784.		
REGRESSION ON VARIANCE		1.075 0.2592	6.938 11.33	-127.2 162.7	814.3 962.7	-1738. 1964.		

ESTIMATOR: $\hat{\mu}_{\text{P}}(0.9994)$ of $\text{Spr}(\text{Data})$ L Laplace RR r.v., $\theta = 02$, $L = 3$ Using Priestly Estimator

Figure 54. Summary Statistics, L-Laplace Samples. Priestley Estimator.

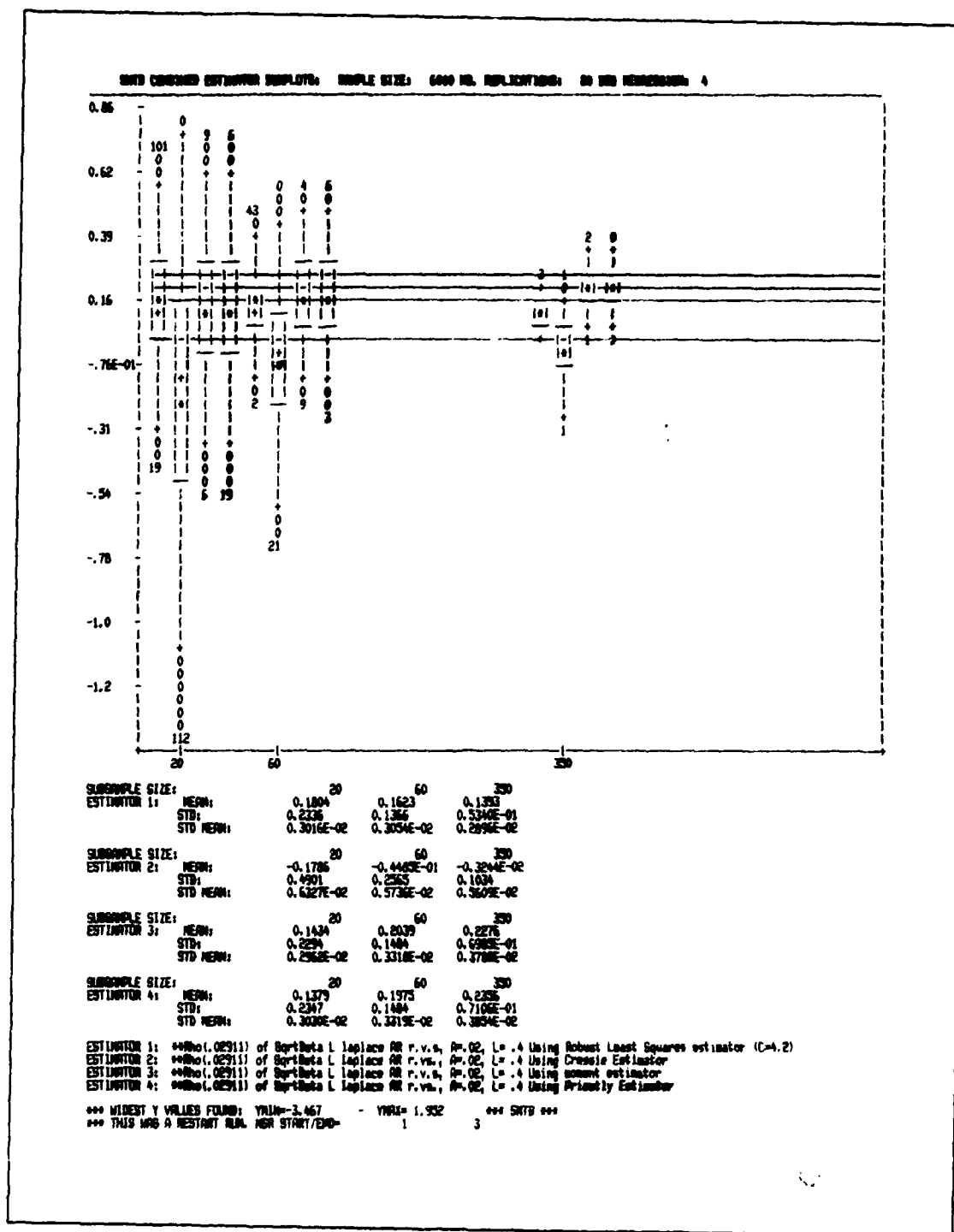


Figure 55. Combined Plot, BELAR(1) Process. $L = 0.4$. $\text{Rho} = 0.02911$.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)							
	50	60	100	150	200	250	300	350
MEAN	0.1779 0.1170E-02	0.1610 0.1570E-02	0.1550 0.0411E-03	0.1467 0.2563E-03	0.1405 0.1417E-02	0.1326 0.1357E-02	0.1267 0.2030E-02	0.1274 0.2403E-02
STD	0.2211 0.1294E-02	0.1206 0.2393E-02	0.1042 0.1734E-02	0.8304E-01 0.9612E-03	0.7004E-01 0.1280E-02	0.6374E-01 0.2217E-02	0.5370E-01 0.1886E-02	0.4888E-01 0.2097E-02
N.B.E	0.8799 0.1474E-02	0.1892 0.1634E-02	0.1634 0.1537E-02	0.1449 0.7683E-03	0.1216 0.1834E-02	0.1274 0.9734E-03	0.1095 0.2543E-02	0.1177 0.2877E-02
SPREAD	0.9206 0.2751E-01	0.6117 0.2847E-01	0.7046 0.4981E-01	0.8988 0.4710E-01	0.9901 0.4197E-01	0.7129 0.5770E-01	0.9400 0.1796	0.3219 0.8111E-01
NUMTODS	0.8975 0.8980E-01	1.189 0.1091	0.8726 0.1991	0.7685 0.1211	0.9469 0.1954	0.9394 0.8833E-01	0.4948 0.1917	-0.2870E-01 0.9777E-01
REL. COV.	-0.7017E-02 0.2074E-02	0.8824E-03 0.1380E-01	0.1105E-01 0.2763E-01	0.9405E-02 0.1750E-01	0.2185E-01 0.1612E-01	-0.2789E-01 0.3134E-01	0.2303E-01 0.4084E-01	-0.2386E-01 0.5483E-01
QUANTILES								
0.010	-0.3832 0.2791E-02	-0.9634E-01 0.8460E-02	-0.9425E-01 0.4396E-02	-0.8395E-02 0.2520E-02	0.2854E-02 0.2401E-02	0.2240E-01 0.4021E-02	0.3463E-01 0.4330E-02	0.3754E-01 0.2532E-02
0.025	-0.2219 0.3603E-02	-0.5736E-01 0.6633E-02	-0.1091E-01 0.2243E-02	0.8637E-02 0.2543E-02	0.9493E-01 0.9930E-03	0.3733E-01 0.1321E-02	0.4990E-01 0.4799E-02	0.5773E-01 0.1939E-02
0.050	-0.1468 0.2803E-02	-0.2657E-01 0.4689E-02	0.1053E-01 0.7132E-03	0.2797E-01 0.2274E-02	0.3913E-01 0.2014E-02	0.3033E-01 0.2910E-02	0.3607E-01 0.2861E-02	0.6392E-01 0.7316E-03
0.100	-0.7238E-01 0.2010E-02	0.1137E-01 0.2840E-02	0.3464E-01 0.1860E-02	0.4980E-01 0.2943E-02	0.5783E-01 0.8137E-03	0.6648E-01 0.2857E-02	0.6933E-01 0.3078E-02	0.8186E-01 0.2720E-02
0.250	0.2544E-01 0.1678E-02	0.6673E-01 0.3941E-02	0.7936E-01 0.1886E-02	0.8723E-01 0.1213E-02	0.9049E-01 0.1706E-02	0.9233E-01 0.3156E-02	0.9823E-01 0.2307E-02	0.1040 0.2137E-02
0.500	0.1466 0.7093E-03	0.1419 0.2241E-02	0.1484 0.1311E-02	0.1263 0.1791E-02	0.1209 0.9868E-03	0.1213 0.2574E-02	0.1237 0.8198E-04	0.1234 0.3067E-02
0.750	0.3181 0.4639E-03	0.2367 0.1794E-02	0.2153 0.2636E-02	0.1964 0.1351E-02	0.1830 0.5763E-03	0.1799 0.1972E-02	0.1683 0.2788E-02	0.1694 0.5884E-02
0.900	0.4932 0.1813E-02	0.3441 0.2010E-02	0.2927 0.4171E-02	0.2573 0.2794E-02	0.2245 0.6398E-02	0.2098 0.1668E-02	0.2004 0.5122E-02	0.1979 0.3032E-02
0.950	0.6015 0.3477E-02	0.4124 0.6192E-02	0.3463 0.4853E-02	0.2975 0.3286E-02	0.2674 0.3340E-02	0.2591 0.3371E-02	0.2383 0.2814E-02	0.2175 0.6298E-02
0.975	0.6963 0.6570E-02	0.4801 0.7949E-02	0.3979 0.6361E-02	0.3363 0.2083E-02	0.2980 0.3979E-02	0.2933 0.7463E-02	0.2649 0.1148E-01	0.2373 0.4993E-02
0.990	0.8211 0.1053E-01	0.3674 0.9621E-02	0.4532 0.8098E-02	0.3939 0.4790E-02	0.3343 0.2772E-02	0.3236 0.7010E-02	0.2849 0.9393E-02	0.2397 0.7236E-02
MEAN OF REGRESSION ON AVERAGES			0.1390 0.3077E-02	-2.326 1.126	757.6 126.0	-0.4140E+05 6570.	-0.1891E+05 2336.	
STD DEV OF REGRESSION			0.8513E-02 0.6128E-03	4.363 0.2746	640.1 30.16	0.3161E+05 1459.	0.1410E+05 666.1	
REGRESSION ON VARIANCE			2.299 1.211	-35.25 49.29	808.4 693.7	-4707. 2987.	9333. 7888.	

ESTIMATOR: @@rho(.02911) of BspData L Laplace RR r.v.s, A=.02, L=.4 Using Robust Least Squares estimator (C=4.2)

Figure 56. Summary Statistics, L-Laplace Samples. Robust Least Squares.

		SUMMARY STATISTICS (MEAN/STD)								J SUPER-REPLICATIONS	
SUBSAMPLE SIZE		20	40	100	150	200	250	300	350		
MEAN		-0.1761 0.0000E-02	-0.4464E-01 0.0000E-02	-0.2191E-01 0.3177E-02	-0.1437E-01 0.0000E-02	-0.7704E-02 0.3007E-02	-0.5377E-02 0.2792E-02	-0.1113E-02 0.1232E-02	-0.0007E-02 0.1002E-02		
STD		0.4870 0.1372E-02	0.0280 0.2700E-02	0.1931 0.2502E-02	0.1902 0.2002E-02	0.1202 0.0041E-02	0.1213 0.4474E-02	0.0000E-01 0.2537E-02	0.0007E-01 0.1771E-02		
N.S.E		0.0003 0.1953E-02	0.0004 0.2900E-02	0.1990 0.2136E-02	0.1020 0.2002E-02	0.1430 0.0000E-02	0.1001 0.3007E-02	0.1001 0.2170E-02	0.1001 0.1232E-02		
SKEWNESS		-0.9000 0.0182E-02	-0.4799 0.2773E-01	-0.2404 0.2367E-01	-0.2904 0.3000E-01	-0.0040 0.0022E-01	-0.1776 0.4000E-01	-0.1703 0.4000E-01	-0.0000 0.0000E-01		
KURTOSIS		1.370 0.3000E-01	0.2431 0.5740E-01	0.0091E-01 0.1102	0.1410 0.1515	0.0000E-01 0.1400	-0.0000E-01 0.0000	-0.0000E-01 0.0000	0.0000E-01 0.0000		
SEA. COR.		-0.7663E-02 0.1290E-01	0.7000E-02 0.2711E-01	-0.1000E-01 0.3000E-02	0.1000E-01 0.1570E-01	0.1000E-02 0.0000E-01	-0.2000E-01 0.3000E-01	-0.1000E-02 0.2120E-01	0.2000E-01 0.4170E-01		
QUANTILES											
0.010		-1.600 0.3007E-02	-0.7444 0.0000E-02	-0.3000 0.0000E-02	-0.4000 0.1500E-01	-0.3000 0.1370E-01	-0.2019 0.1200E-01	-0.2000 0.2340E-02	-0.2000 0.5000E-02		
0.025		-1.307 0.3000E-02	-0.6000 0.4100E-02	-0.4370 0.1007E-01	-0.3400 0.1370E-01	-0.2000 0.0000E-02	-0.2000 0.1100E-01	-0.1000 0.1000E-01	-0.1000 0.1000E-01		
0.050		-1.007 0.3000E-02	-0.4000 0.0000E-02	-0.3000 0.2300E-02	-0.2000 0.0000E-02	-0.2000 0.0000E-02	-0.2000 0.0000E-02	-0.2000 0.0000E-02	-0.2000 0.0000E-02		
0.100		-0.0000 0.0000E-02	-0.3700 0.1240E-01	-0.0000 0.3000E-02	-0.2100 0.1101E-02	-0.1000 0.0000E-02	-0.1000 0.1040E-01	-0.1000 0.3000E-02	-0.1000 0.7470E-02		
0.250		-0.4519 0.3000E-02	-0.2079 0.4514E-02	-0.1400 0.3400E-02	-0.1119 0.4000E-02	-0.1010 0.3170E-02	-0.0377E-01 0.1000E-01	-0.0300E-01 0.0000E-02	-0.0300E-01 0.0000E-02		
0.500		-0.1000 0.3000E-02	-0.0000E-01 0.2257E-02	-0.0000E-02 0.3000E-02	-0.7700E-02 0.3000E-02	-0.2100E-02 0.1040E-02	-0.1000E-02 0.1040E-02	-0.1000E-02 0.0000E-02	-0.1000E-02 0.0000E-02		
0.750		0.1703 0.7400E-03	0.1370 0.1400E-02	0.1101 0.3700E-02	0.0000E-01 0.0000E-02	0.0000E-01 0.0000E-02	0.0000E-01 0.0000E-02	0.0000E-01 0.0000E-02	0.0000E-01 0.0000E-02		
0.900		0.2003 0.8170E-03	0.0000 0.2471E-02	0.2100 0.3000E-02	0.1047 0.2100E-02	0.1000 0.7400E-02	0.1000 0.3771E-02	0.1000 0.0000E-02	0.1000 0.0000E-02		
0.950		0.4000 0.3510E-02	0.2000 0.2397E-02	0.2797 0.9100E-02	0.2313 0.0000E-03	0.0000 0.0000E-02	0.1000 0.0000E-02	0.1000 0.0000E-02	0.1000 0.0000E-02		
0.975		0.3000 0.2300E-02	0.4015 0.7463E-02	0.3003 0.1191E-01	0.2703 0.7070E-03	0.0000 0.1000E-01	0.0000 0.1000E-01	0.1707 0.9570E-02	0.1570 0.6990E-02		
0.990		0.6347 0.0000E-02	0.4575 0.1399E-01	0.3770 0.1450E-01	0.3003 0.9700E-03	0.0000 0.2111E-01	0.0000 0.1153E-01	0.0000 0.2773E-02	0.0000 0.0000E-02		
MEAN OF REGRESSION ON AVERAGES			0.2970E-02 0.6470E-02	-1.799 4.637	-100.0 763.9	310.0 0.3904E+05	114.0 0.1750E+05				
STD DEV OF REGRESSION			0.1493E-01 0.7500E-03	7.766 0.6230	117.5 121.5	0.9942E+05 600.0	0.0000E+05 317.4				
REGRESSION ON VARIANCE			2.630 3.566	39.61 140.6	-509.4 210.0	200.0 0.1212E+05	-79.33 0.0000E+05				
ESTIMATOR: **rho(.00911) of SqrtBeta L Laplace RR P.v.s., R=.02, L=.4 Using Cressie Estimator											

Figure 57. Summary Statistics, L-Laplace Samples. Cressie Estimator.

SUBSAMPLE SIZE	SUMMARY STATISTICS (MEAN/STD)								J SUPER-REPLICATIONS	
	20	60	100	150	200	250	300	350		
MEAN	0.1420 0.234E-03	0.2037 0.136E-02	0.2123 0.461E-02	0.2246 0.274E-02	0.2295 0.253E-02	0.2321 0.300E-03	0.2339 0.313E-02	0.2362 0.243E-02		
STD	0.2313 0.121E-02	0.1390 0.258E-02	0.1208 0.129E-02	0.1091 0.861E-03	0.885E-01 0.111E-02	0.779E-01 0.135E-02	0.671E-01 0.149E-02	0.574E-01 0.151E-02		
N.B.E	0.2579 0.107E-02	0.2202 0.734E-03	0.2195 0.135E-02	0.2197 0.288E-02	0.2191 0.382E-02	0.2182 0.218E-03	0.2195 0.254E-02	0.2149 0.193E-02		
SHRINKAGE	-0.947E-01 0.166E-01	-0.2217E-01 0.293E-01	0.4351E-01 0.953E-01	0.1094 0.629E-01	0.463E-01 0.246E-01	0.1221 0.641E-01	0.1316 0.118E-01	0.778E-01 0.101E-01		
HURTOSIS	-0.667E-01 0.699E-01	-0.977E-01 0.513E-01	-0.1081 0.157E-01	0.1237 0.494E-01	0.2014 0.206E-01	0.6189 0.346E-01	-0.110E-01 0.189E-01	0.195E-01 0.239E-01		
SKW. COV.	-0.673E-02 0.362E-02	-0.297E-02 0.547E-02	-0.297E-01 0.253E-01	-0.440E-01 0.301E-02	0.170E-01 0.707E-02	0.770E-02 0.269E-01	-0.430E-01 0.259E-01	-0.627E-02 0.132E-02		
QUANTILES										
0.010	-0.2041 0.403E-02	-0.1579 0.147E-01	-0.3916E-01 0.613E-02	-0.301E-02 0.590E-02	0.281E-01 0.406E-02	0.283E-01 0.791E-02	0.280E-01 0.376E-02	0.1010 0.406E-02		
0.025	-0.2102 0.288E-02	-0.209E-01 0.791E-02	-0.160E-01 0.751E-02	0.283E-01 0.693E-02	0.363E-01 0.197E-02	0.707E-01 0.490E-02	0.1083 0.166E-02	0.1191 0.298E-02		
0.050	-0.2407 0.704E-03	-0.204E-01 0.583E-02	0.138E-01 0.588E-02	0.287E-01 0.374E-02	0.689E-01 0.144E-02	0.1060 0.284E-02	0.1279 0.319E-02	0.1397 0.304E-02		
0.100	-0.1360 0.227E-02	0.137E-01 0.726E-02	0.540E-01 0.677E-02	0.967E-01 0.165E-02	0.1104 0.256E-02	0.1218 0.285E-02	0.1497 0.491E-02	0.1619 0.282E-02		
0.250	-0.157E-01 0.880E-03	0.1014 0.363E-02	0.1282 0.519E-02	0.1360 0.317E-02	0.1679 0.111E-02	0.1771 0.732E-03	0.1885 0.497E-02	0.1979 0.459E-02		
0.500	0.1416 0.357E-03	0.2021 0.243E-02	0.2136 0.396E-02	0.2227 0.289E-02	0.2274 0.413E-02	0.2354 0.129E-02	0.2316 0.411E-02	0.2351 0.384E-02		
0.750	0.3036 0.994E-03	0.3089 0.879E-03	0.2962 0.586E-02	0.2919 0.590E-02	0.2891 0.281E-02	0.2843 0.146E-02	0.2801 0.298E-02	0.2764 0.161E-02		
0.900	0.4413 0.941E-03	0.3969 0.217E-02	0.3666 0.580E-02	0.3525 0.302E-02	0.3409 0.579E-02	0.3322 0.116E-02	0.3247 0.128E-02	0.3119 0.314E-02		
0.950	0.5199 0.305E-02	0.4487 0.570E-03	0.4103 0.504E-02	0.3890 0.228E-02	0.3735 0.483E-02	0.3623 0.341E-02	0.3495 0.163E-02	0.3392 0.901E-03		
0.975	0.5779 0.615E-02	0.4957 0.746E-02	0.4500 0.897E-02	0.4221 0.553E-02	0.4147 0.564E-02	0.3912 0.582E-02	0.3678 0.466E-02	0.3477 0.219E-02		
0.990	0.6531 0.864E-02	0.5516 0.200E-02	0.4953 0.148E-01	0.4635 0.286E-02	0.4418 0.293E-02	0.4279 0.448E-02	0.4014 0.125E-01	0.3692 0.197E-02		
MEAN OF REGRESSION ON AVERAGES		0.2347 0.156E-01	1.868 0.200	-780.0 1221.		0.430E+05 0.599E+05	0.198E+05 0.255E+05			
STD DEV OF REGRESSION		0.966E-02 0.149E-02	5.081 0.7253	785.6 94.44		0.204E+05 4522.	0.173E+05 2014.			
REGRESSION ON VARIANCE		1.782 0.2830	-3.906 27.95	11.63 363.1		-127.2 2946.	363.0 7500.			

EXTINCTION: 000001.029111 of SuperData L Laplace AN r.v.s, $\alpha=0.2$, $L=0.4$ Using moment estimator

Figure 58. Summary Statistics, L-Laplace Samples. Moment Estimator.

SUMMARY STATISTICS (MEAN/STD)								
J SUPER-REPLICATIONS								
SUBSAMPLE SIZE	20	60	100	150	200	250	300	350
MEAN	0.1405 0.1382E-02	0.2002 0.1353E-02	0.2109 0.907E-03	0.2245 0.4851E-03	0.2279 0.4247E-02	0.2319 0.4087E-02	0.2345 0.3843E-03	0.2346 0.2803E-02
STD	0.2340 0.1786E-02	0.1487 0.7643E-03	0.1201 0.8251E-03	0.1004 0.5783E-03	0.8932E-01 0.8787E-03	0.8023E-01 0.8047E-02	0.6932E-01 0.6537E-03	0.5641E-01 0.1561E-02
N.S.E	0.2732 0.1604E-02	0.2257 0.1364E-02	0.2246 0.1179E-02	0.2197 0.1763E-03	0.2199 0.3643E-02	0.2181 0.4047E-02	0.2157 0.8843E-03	0.2132 0.1744E-02
BIASNESS	0.9304E-02 0.5823E-01	-0.1772E-01 0.3182E-01	0.3048E-01 0.2282E-01	0.9373E-01 0.2147E-01	0.8448E-01 0.6873E-01	0.8231E-01 0.6543E-01	0.8032E-02 0.4984E-01	0.1282 0.2582E-01
FLUCTU8	0.1649 0.2453	-0.7432E-01 0.1203E-01	-0.8312E-01 0.2572E-01	0.2323 0.2144	0.1148 0.1889	-0.2792E-01 0.8612E-01	-0.1283 0.1479	-0.2582 0.4382E-01
SEL. COV.	0.3845E-02 0.3277E-02	0.1477E-01 0.1892E-01	0.9452E-02 0.1042E-02	-0.6773E-02 0.1382E-01	-0.8323E-01 0.8032E-01	-0.7443E-02 0.2312E-02	-0.1782E-02 0.2473E-01	-0.2567E-01 0.2582E-01
SUBSAMPLES								
0.010	-0.3982 0.5452E-02	-0.1442 0.5763E-02	-0.5441E-01 0.1211E-02	-0.3544E-02 0.3130E-02	0.2365E-01 0.6614E-02	0.4887E-01 0.8932E-01	0.7812E-01 0.3083E-02	0.1025 0.1114E-01
0.025	-0.3132 0.5641E-02	-0.8673E-01 0.5743E-02	-0.1284E-01 0.3810E-02	0.8282E-01 0.2782E-02	0.9482E-01 0.8062E-02	0.6794E-01 0.2943E-02	0.1002 0.2382E-02	0.1232 0.2812E-02
0.050	-0.2434 0.5712E-02	-0.4162E-01 0.1350E-02	0.1743E-01 0.1284E-02	0.6147E-01 0.2823E-02	0.8821E-01 0.5447E-02	0.9892E-01 0.1510E-02	0.1192 0.8403E-02	0.1452 0.4007E-02
0.100	-0.1939 0.4662E-02	0.8070E-02 0.4241E-03	0.6357E-01 0.1560E-02	0.9781E-01 0.4613E-03	0.1162 0.4154E-02	0.1211 0.1148E-02	0.1408 0.2382E-02	0.1688 0.1782E-02
0.250	-0.1984E-01 0.2134E-02	0.9870E-01 0.3433E-02	0.1264 0.7951E-03	0.1360 0.1022E-02	0.1693 0.4518E-02	0.1778 0.4377E-02	0.1878 0.1730E-02	0.1939 0.1064E-02
0.500	0.1400 0.2139E-02	0.1979 0.2783E-02	0.2193 0.1890E-02	0.2237 0.8673E-03	0.2275 0.4253E-02	0.2313 0.4636E-02	0.2346 0.8232E-03	0.2331 0.2534E-02
0.750	0.2032 0.1002E-02	0.3042 0.2994E-02	0.2017 0.1323E-02	0.2903 0.1460E-02	0.2992 0.6577E-02	0.2850 0.5164E-02	0.2879 0.1982E-02	0.2792 0.2312E-02
0.900	0.4421 0.1276E-02	0.3891 0.2461E-02	0.3707 0.4884E-02	0.2932 0.2514E-02	0.3470 0.5893E-02	0.2317 0.4432E-02	0.2884 0.2536E-02	0.3088 0.1624E-02
0.950	0.5162 0.2574E-02	0.4421 0.2862E-02	0.4193 0.3630E-02	0.3876 0.2189E-02	0.3814 0.4064E-02	0.2685 0.7570E-02	0.3489 0.4954E-02	0.3293 0.2592E-02
0.975	0.5840 0.2749E-02	0.4848 0.3031E-02	0.4593 0.4530E-02	0.4351 0.3054E-02	0.4106 0.1586E-02	0.2897 0.1284E-01	0.2879 0.3078E-02	0.2537 0.2467E-02
0.990	0.6647 0.8034E-02	0.5519 0.3813E-02	0.5019 0.3853E-02	0.4792 0.2953E-02	0.4923 0.3512E-02	0.4198 0.9157E-02	0.4057 0.1280E-01	0.3727 0.8780E-02
MEAN OF REGRESSION ON AVERAGES		0.2390 0.4732E-03	-1.776 1.491	-18.25 883.8	-146.4 0.1463E+05	-1884. 6612.		
STD DEV OF REGRESSION		0.1126E-01 0.1432E-02	5.362 0.8504	812.1 119.1	0.4031E+05 3286.	0.1803E+05 2224.		
REGRESSION ON VARIANCE		0.8098 0.7878	40.30 35.63	-648.8 351.4	379. 2364.	-7468. 6821.		
ESTIMATOR: control(02911) of SuperBeta L Laplace AB P.v.m., AB, 02, L= .4 Using Priestly Estimator								

Figure 59. Summary Statistics, L-Laplace Samples. Priestley Estimator.

VI. CONCLUSIONS

A. SIMTBED.

These types of statistical simulations would be largely infeasible without some sort of aids to the user. With routines like SIMTBED, these simulations can be interesting investigations. Granted, SIMTBED can be difficult to understand for the beginning simulator. But, once familiarity is gained all sorts of investigations and simulations are within the realm of the user. Now, we have increased the capability of SIMTBED by providing the user the capability to use his personal computer and color output devices in statistical simulations, which is often more convenient and cost effective. As technology proceeds, these types of programs will attract more attention and produce more for the user community.

B. SERIAL CORRELATION ESTIMATION.

These simulation results do not, in the opinion of this author, provide any evidence to indicate that the more esoteric and analytically intractable estimators of serial correlation are any better, with regard to producing the "correct" results, than the well-understood estimators the standard statistical theory has produced. In fact, they may be worse. This is demonstrated by the behavior of the Cressie estimator and the robust regression approach versus the familiar moment and less familiar MLE estimators. Further, if the user interested in serial correlation has additional information about his samples, he can, with these results, determine the behavior of these estimators on his samples. In order to get good estimates of serial correlation, the following advice is offered:

- Use the largest possible sample size. If possible, it is desirable to be outside the small-sample bias effects.
- Try and ascertain the distributional properties of the sample/population. If it is distinctly non-Normal, then recognize there will be a corresponding lack of accuracy in the estimate.
- If possible, obtain multiple samples. Multiple estimates give better overall indications of the correlation.

C. FURTHER EXPERIMENTATION.

It would be interesting to study the "GM-estimate" of Denby and Martin [Ref. 9, p. 141]. Other non-Normal distributions can also be investigated. Given

sufficient time, these simulations can be carried further, in terms of sub-sample sizes, and number of super-replications. Finally, there are probably other esoteric estimators of serial correlation in the literature which could be studied, as this is an important field in which to conduct research.

APPENDIX A. USER'S GUIDE TO SIMTBED, A SIMULATION TEST BED

A. OVERVIEW.

The simulation test bed program used in this thesis, SIMTBED, is designed to aid in the assessment of the distributional properties of any user-supplied statistical estimator based on i.i.d random variables or on time series. It is a FORTRAN subroutine, and provides analysis of estimators at various sample sizes. It controls the user-provided generating routines so that the estimator can be computed many times to study its distribution, moments (through the 4th central moment), and the variability of the estimates of these values. A regression model for the mean and variance can also be constructed. In general, any statistical simulation provides voluminous output, and this approach is designed to compactify the output and make the important features apparent. Graphic displays of the behavior of the user estimators is accomplished using line printer graphics, and the system is designed for the IBM personal computer family of computers. Output consists of a series of plots for each estimator (box plots, percentile plots, normalized quantile plots), summary tables for super- replications, a combined boxplot graph for all estimators, and optionally bivariate histograms for pairs of up to three estimators. If known values of the estimators are provided, the mean squared error from these known values can be obtained.

1. History.

SIMTBED began in 1981 with a mainframe version by Lewis, Orav, and Uribe. The first personal computer version was presented in a thesis by Hans-Walter Drueg, based on the regression adjusted graphics and estimation methodology of Lewis and Heidelbergberger. It has subsequently been moved to the IBM PC, and modifications include:

- A capability for super-replications to estimate the variability of the estimates of the quantiles, moments, and regression parameters.
- A restart capability for building super-replication simulations over time using files.
- Use of files to capture super-replication output for further processing by other systems.
- Bivariate histograms.
- Most recently, the use of color to compare the estimators with each other in the same plot.

This work reflects changes in data processing technology, and is largely the result of work by P.A.W. Lewis, E.J. Orav, and L. Uribe, while the most recent additions to the system were added as part of this thesis by the author. The remainder of this appendix consists of a discussion of the features of SIMTBED, and how it is used.

B. FEATURES OF SIMTBED.

In order to use SIMTBED, the user must supply the driver, a program which sets the parameters (listed below) and calls SIMTBED, and the estimator routines, which take a random number seed and sample size, and generate one result which is the estimator, based on the sample size. These are referred to as sub-sample sizes, for the following reason.

1. Sample Sizes.

SIMTBED takes a global sample size, N , (5000, for example), and then sections it according to various subsample sizes $NE()$, and calls the estimator routine(s) the appropriate number of times. In this way multiple evaluations of the estimator are obtained. If the subsample size were 100, and N were 5000, then 50 evaluations of the estimator, based on a sample size of 100 would be obtained. This process can be replicated up to 100 times, through M , the number of replications, so for example, if N is 5000, and NE is 50, and M is 20, then 2000 evaluations of the estimator will be generated. Up to eight different subsample sizes can be specified, and will be used for each of up to five estimators. These evaluations of the estimator are stored in an array, and SIMTBED will obtain statistics from them. The array must hold at least $(N \times M) / NE(1)$, where $NE(1)$ is the first, and smallest subsample size. The subsample sizes are in increasing order, which is conducive to the graphing process.

2. SIMTBED Estimator Statistics.

SMTB computes the mean of the stream of estimators, for each subsample size. Also, the standard deviation is computed using $n-1$ weighting. The standard error of the mean is computed, as σ / \sqrt{n} . The mean squared error (MSE) is optionally estimated using the formula

$$\hat{MSE} = \sqrt{(\hat{VAR} + (\hat{\mu} - VMSE)^2)} \quad (A-1)$$

where $VMSE$ is the known input value of the estimator, again for each subsample size. The coefficients of skewness and kurtosis are also computed, using unbiased expressions.

3. Graphs.

a. *Boxplots.*

A boxplot graph is generated for each estimator, depicting boxplots for each subsample size, showing the mean, median, inter-quartile range, and outlier information. The vertical scale can be set by the user, or SIMTBED will scale the graph according to the largest values encountered. The graphs can be fixed to all have the same scale, or each can be scaled individually. The boxplots can be reduced. That is, the outliers are reported as a numeric count at the tail of the boxplot instead of representing each by a separate symbol. This is often necessary for highly variable estimators. If super-replications are being performed, up to three such plots for each estimator can be obtained.

b. *Quantiles.*

A plot of eleven quantiles is prepared next. They are depicted in the plot, as well as tabulated below the graph. The lag one serial correlation (moment estimator) is also listed. A normalized quantile plot is also available.

c. *Other Plots.*

If requested, bivariate histograms for the pairwise combinations of the first three estimators can be obtained to graphically assess relationships between the different estimators. One plot is prepared for all the subsample sizes, giving the possibility of 24 histograms if the full complement of subsample sizes is prepared. The bivariate histogram also lists four measures of association: covariance, correlation coefficient, Spearman's rank correlation coefficient, and Kendall's tau coefficient. Five tests for equidistribution are included: Kolmogorov-Smirnov, Wald-Wolfowitz, Mann-Whitney, Wilcoxon, and Siegel-Tukey tests. The overall univariate statistics are also reproduced with these plots: mean, median, variance, standard deviation, range, etc.

d. *Combined Estimator Boxplots.*

Finally, a graph of selected boxplots for all estimators together can be obtained, so the relations between them at various sample sizes can be better studied. If a color printer is available, each estimator will have a different color. Up to three of the subsample sizes can be plotted, for up to five estimators, all on the same graph. If regression is being performed, the asymptote lines will be included, in the appropriate color for each estimator. These regression lines are merely reproductions of the full regression SIMTBED performed when the estimators were simulated, and are based on the original SIMTBED regression. No additional simulation or computation is required to produce these combined plots.

4. Regression.

The regression performed by SIMTBED follows the methodology developed by Heidelberger and Lewis (see the body of the thesis, Chapter 3, Section B.). Regression is performed on the mean of estimates using the data from the subsample sizes according to the equation:

$$E[\theta_m] = \theta + \left(\frac{a_1}{m}\right) + \left(\frac{a_2}{m^2}\right) + \left(\frac{a_3}{m^3}\right) + \dots \quad (A-2)$$

the degree of regression is the number of terms of the equation used. In equation (2), θ is the regression estimate of the estimator. This regression is performed for each replication (M), and with these independent data points, the variance and standard deviation of the coefficients of equation (2) can be estimated. These equation coefficients are reported with the standard boxplot graphs SIMTBED produces.

The regression for the variance of the estimator is performed once, using all $M*N$ data points, according to the equation

$$\text{Var}[\theta_m] = \left(\frac{b_1}{m}\right) + \left(\frac{b_2}{m^{1.5}}\right) + \left(\frac{b_3}{m^2}\right) + \left(\frac{b_4}{m^{2.5}}\right) + \dots \quad (A-3)$$

These coefficients are also reported in the plot summary.

5. Super-replications.

The simulation process just described can be wholly repeated many times, referred to as super-replications. This makes it possible to get precision information, in the form of standard deviation, for all the statistics SIMTBED computes, instead of just the regression adjusted estimate of the mean of the estimator distribution. With super-replications, averages and standard deviations are available for all the moments, the serial correlation of the replications, and all eleven quantiles for all the subsample sizes, and the regression coefficients as well. If specified, individual run boxplot graphs and quantile plots can be obtained for the first three super-replications, or only for the first. These super-replication summary statistics can be stored in a file in tabular form for further processing by any number of other means, or for archival purposes.

Since the performance of super-replications can be quite time-intensive, SIMTBED has the capability to write the parameters and summary data to a file for super-replications so far performed, and will then restart from where it left off, producing

more super-replications on the same simulation. In this way, the precision needed can be achieved piecewise, at the convenience of the user.

6. Random Number Generation.

Since statistical simulation is dependent on the production of pseudo-random numbers, SIMTBED makes available routines for generating several common distributions of random variables. Among these are uniform, normal, Laplace, Cauchy, gamma, Pareto, beta, geometric, Poisson, and binomial random variables. These random number generators are based on the well tested uniform random number generator LLRANDOM II. These random number generators are linked with the SIMTBED subroutines after compilation, and the user can thus use any linker/library utility to insert or remove any of these routines, or add new random number generators (i.e. IMSL) at will.

C. USE OF SIMTBED.

To use SIMTBED you must write a FORTRAN program which has a CALL statement to the SIMTBED subroutine. This is called a driver program, and your driver must do several things for SIMTBED to operate properly. An example driver is included as figure 1. The driver must do the following:

- Initialize and set appropriate values for the arguments of SIMTBED (see Table 1). This is done through the REAL, INTEGER, DATA, and direct assignment FORTRAN statements.
- Declare the scratch array of the correct size for SIMTBED to use. This size is determined as $N * M / NE(1)$, since $NE(1)$ is the smallest sample size, and will result in the largest number of evaluations of your estimator.
- Declare as EXTERNAL the names of the estimator routines provided to SIMTBED.

1. SIMTBED Arguments.

The argument types for SIMTBED are listed below, along with their function and possible values. In general, the names used here are not required, but they must match in variable type and position in the calling statement, and the arrays must be of the correct dimension. For example, NCOLORNDX is not required to be named as such, but it must be an INTEGER(3) array, and be in the proper order in the argument list of the calling statement.

2. Calling Statement.

The calling statement to invoke SIMTBED is:

```

CALL SIMTBED(ISEED1,ISEED2,ISEED3,ISEED4,ISEED5,Y,N,M,NE,
*L,D,NSR,RG,SEI,SVS,YMIN,YMAX,NEST,GEST1,TTL1,GEST2,TTL2,
*GEST3,TTL3,GEST4,TTL4,GEST5,TTL5,IFIL,NPRT,MSE,VMSE,IPR,
*VMX1,VMX2,VMX3,VMX4,VMX5,IBIV,RSTRT,ICOLOR,IBWPRT,NCPRT,
* NCOLRNDX)

```

3. Estimator Routines.

The user must also provide a number (up to five) of estimator subroutines to SIMTBED, for generating the random numbers and the estimator, based on the sample size. The argument list of the estimator routine must have the following structure (the name is up to the user, of course):

```

SUBROUTINE GEST1(ISEED,N,EVAL)

```

where GEST1 is the declared EXTERNAL name, ISEED is a REAL*8 (double precision) number for the random number seed, N is an INTEGER sample size to use, and EVAL is a REAL*4 result, the estimator evaluated based on sample size N. Within the routine the user is free to do anything necessary to generate the random process and obtain the estimator (could even be non-random nature). It is common to have calls to random number generators and some follow-on calculations (for example, obtaining the fourth moment of standard normal random numbers). It is often of interest to determine how many times this user routine will be called. The value N will be each NE(I) in sequence, so the number of calls to this subroutine will be $N * M / NE(I)$, for each sub-sample size. This is why the Y array is required to be at least a certain size. It holds the results from the calls to this routine. Notice there is no provision for other parameters to be passed to the estimator routine. If the user wishes to parameterize the estimator routines through the driver program (useful for complicated and related estimators), COMMON storage is available for this purpose. SIMTBED does not use any COMMON storage.

4. Files.

SIMTBED has the ability to use three files in addition to the console (UNIT 5). These are for normal output (UNIT 6), restart operations (UNIT 2), and super-replication recording results (UNIT 1). Each of these files is used in a different way. They are all created with the OPEN statement. The UNIT 6 file will contain carriage control characters for visual display devices (printers, CRTs), and can be a file, or an actual unit. We recommend using a file to prevent a printer error from causing a program interrupt and loss of data. If a file is used it must be printed with respect given to

the carriage control characters, or the plots will not be correct (the DOS PRINT command suffices nicely). For example

```
OPEN(06,FILE='RESULTS.TXT',FORM='FORMATTED')
```

where ACCESS of SEQUENTIAL is the default and not specified. Also, no error handling is present in this example. The file used for output of super-replications is also of type FORMATTED, but is written to UNIT 1, and has no carriage control characters imbedded. The result is a normal ASCII file that can be read by any text editor. The file used for restart is different, however. Using UNIT 2, this file is UNFORMATTED, and can only be read by another FORTRAN program. Since type FORMATTED is the default for sequential files, the user must give this specific declaration in the OPEN statement, or an error will occur. For example,

```
OPEN(02,FILE='START.DAT',FORM='UNFORMATTED',ACCESS=
'SEQUENTIAL')
```

 will cause the correct file type to be created. The data in this file is written in internal storage form, and is inaccessible to the user.

5. Using Random Numbers.

The random number generators available in SIMTBED are based on the uniform random number LLRANDOMII, as mentioned earlier. What will be listed here is the CALL statement and arguments required to generate a random variable stream, and the form of the variables generated. For all the calls, DSEED is a REAL*8 seed, N is the number of variables generated, and X is a real array of size at least N, containing the random numbers after the call.

- For uniform random numbers, use CALL LRNDPC(DSEED,X,N) to obtain uniform [0, 1] random numbers.
- For normal random numbers, use CALL LNORPC(DSEED,X,N) to obtain standard normal random numbers.
- For Laplace random numbers, use CALL LLAPPC(DSEED,X,N) to obtain Laplace random numbers with mean 0 and standard deviation SQRT(2).
- For Cauchy random numbers, use CALL LCHYPC(DSEED,A,N) to obtain Cauchy random number with location 0 and scale 1
- For Gamma random numbers, use CALL LGAMPC(DSEED,X,N,K) to obtain Gamma random numbers with shape K and scale 1. Transform to Gamma(k,b) by dividing by b.
- Pareto random numbers are available by the statement CALL LPARPC(DSEED,X,N,A) where A is the shape parameter of the Pareto distribution.

- Beta random numbers are obtained with CALL LBETPC(DSEED,X,N,P,Q) where P and Q are the parameters of the Beta distribution.
- Geometric (discrete) random variables are available with CALL LGEOPC(DSEED,A,N,P) where P is the parameter of the geometric distribution.
- Generate Poisson random variables with CALL LPOIPC(DSEED,A,N,U) where U is the mean of the desired distribution. The method used to generate these variables uses a table lookup, and requires some front end 'overhead' to set up. For best efficiency, generate as many variables as possible at one time.
- To generate Binomial random numbers, CALL LBINPC(DSEED,X,N,NIND,P) is required. NIND is an INTEGER, for the parameter number of trials. P is the p parameter for the binomial distribution.
- For random variables other than those listed here, or that cannot be obtained through some transformation, the user must provide the routine to generate them, usually starting with a call to LRNDPC.

6. Running SIMTBED.

In general, to run a driver with SIMTBED, the driver must be compiled and linked with the SIMTBED library. For most compilers there is an option for large arrays. This should be used if the dimensions of the Y array are large. The reader is referred to the body of the thesis for examples of SIMTBED output.

D. SIMTBED ARGUMENTS AND PARAMETERS.

1. ISEED1, ISEED2, ISEED3, ISEED4, ISEED5. DOUBLE PRECISION (REAL*8) reals. These are the seeds used to start the random number streams used by SIMTBED. Using the same seed will produce the same results. Use the same number for the seed to get the same random numbers for each estimator.
2. Y. REAL*4 array. The scratch array used by SIMTBED to carry the results of your estimator when called.
3. N. INTEGER. The "global" sample size.
4. M. INTEGER. The number of replications of each subsample size to perform. M cannot exceed 100.
5. NE. INTEGER array of size 8. The subsample sizes for SIMTBED to use. Must be in ascending order. If less than 8 are used, pad with zeros.
6. L. INTEGER. The number of subsample sizes to use. Must be between 1 and 8.
7. D. INTEGER. The degree of regression (number of terms in regression equation). Can be from 1 to 6. If there are not enough subsamples ($D \leq L - 1$) to establish the regression, SIMTBED will lower the degree of regression specified in the call. Using $D=0$ will suppress the regression.
8. NSR. INTEGER. Number of super-replications to perform. Must be at least one. If only one super-replication is used, no summary will be generated.

9. RG. INTEGER. Reduced Graphics. 1 = Yes. 0 = No. In reduced graphics, SIMTBED will put the number of outliers at the end of the boxplot instead of plotting each one. This makes the scale of the plot closer to the interquartile range, and thus easier to interpret for highly variable estimators.
10. SEI. INTEGER. Scale Estimators Individually. 1 = Yes. 0 = No. When set to zero, plots for all estimators will have the same scale (the max of the set of estimators). This is required for color combined plots, so if color is selected, this flag will be reset.
11. SVS. INTEGER. Set Vertical Scale. 1 = Yes. 0 = No. If SVS = 1, the user will set the vertical scale with the values YMIN and YMAX. Otherwise, SIMTBED determines these values.
12. YMIN. REAL. Minimum y axis value for SVS = 1.
13. YMAX. REAL. Maximum y axis value for SVS = 1.
14. NEST. INTEGER. Number of Estimators. Must be between 1 and 5. The appropriate arguments for the number of estimators must be defined. Otherwise, dummy arguments can be used (ISEED, GEST, TTL, VMX).
15. GEST1, GEST2, GEST3, GEST4, GEST5. EXTERNAL. These are the names of the estimator routines, passed to SIMTBED in the calling statement. For unused estimators, duplicate the defined names.
16. TTL1, TTL2, TTL3, TTL4, TTL5. CHARACTER*120 (max). A label of the estimator routine, to be placed on the plots.
17. IFIL. INTEGER. 1 = Yes. 0 = No. Yes will write the super-replication statistics to the file declared on UNIT 1, for further processing. This is a formatted ASCII file.
18. NPRT. INTEGER. Print Detail. 1 = Yes. 0 = No. Yes will print full plots for the first three super-replications, and normalized quantile plots in addition to the standard quantile plots. No will print full plots only for the first super-replication. Regardless, the information for the color combined plots comes from the first super-replication.
19. MSE. Mean Squared Error. INTEGER. 1 = Yes. 0 = No. Yes will compute the mean squared error of the estimator at each sample size from the user input known values. No ignores the user input known values.
20. VMSE. Vector of Mean Squared Error. REAL array (8,5).
The known values of each estimator at each subsample size, for SIMTBED to compare with the generated results, based on MSE flag. Initialize to zeros for unused portions of this array.
21. IPR. Print Percentile Plots. 1 = Yes. 0 = No. Yes will cause SIMTBED to count the frequency of occurrence where the evaluated estimator is less than each of four specified values (the percentiles), for each subsample size. These are then converted to probabilities, and a plot is produced.
22. VMX1, VMX2, VMX3, VMX4, VMX5. REAL array (8,4) each. These are user supplied values for the percentile plot calculations. SIMTBED will obtain the frequency that the estimator is less than each value and prepare a percentile plot.

23. IBIV. INTEGER. Bivariate Histograms. 1 = Yes. 0 = No. Yes causes bivariate histograms to be produced for each combination of the first three estimators, at each subsample size.
24. RSTRT. Restart. INTEGER. 1 = Yes. 0 = No. Yes results in a SIMTBED write to the file on UNIT 2 of the super-replication final results, so that the simulation can be continued from this point later. For subsequent runs, Yes causes the file on UNIT 2 to be read, and the parameters checked for agreement. Processing continues with the next super-replication. For example, if 3 is used for NSR, then using 8 for the next run for NST will cause 5 more super-replications to be performed. Using a value for NSR for a later run less than that used on an earlier run causes a message to be displayed and processing stops.
25. ICOLOR. INTEGER. Color Combined Printing. 1 = Yes. 0 = No. Yes causes combined boxplots of all the estimators to be produced. The subsample sizes used are determined by another array. SEI is set to 0. Printer control codes to set colors for standard IBM dot matrix printers are used to print each estimator in a different color. On non-color printers these codes are ignored.
26. IBWPRT. INTEGER. Standard Printing. 1 = Yes. 0 = No. Yes causes the standard printing of boxplots for each estimator in sequence. No suspends this printing for brevity. Bivariate histograms and super-replications summary plots will still be generated. This is used in conjunction with the ICOLOR flag to produce output which will consist of *only* the color combined plot. This way, if the experimenter is only interested in obtaining this plot, he will not have to print all the previously generated plots to obtain it. (This actually came about as an aid during development of the color features.)
27. NCPRT. INTEGER. Number of clusters to print. Must be between 1 and 3. This is the number of subsample sizes for which to print combined boxplots.
28. NCOLRNDX. INTEGER array, size 3. Each entry must be between 1 and 8, in increasing order. Do not duplicate entries. This specifies which of the subsample sizes are used in the combined plots. For example, DATA NCOLRNDX/2,3,4/ will cause SIMTBED to use the second, third, and fourth subsample sizes in the combined plots.

This concludes the discussion of SIMTBED.

APPENDIX B. METHOD USED TO PROGRAM COLOR COMBINED BOXPLOTS IN SIMTBED

A. INTRODUCTION.

This appendix describes the programming approach I used to incorporate the features we wanted into SIMTBED, which took approximately three months of analysis of the SIMTBED program and its approach to statistical simulation. There were four basic aspects involved in incorporating color printing into SIMTBED:

- Understand the architecture and organization of the existing SIMTBED package.
- Understand the method of producing graphics with line printers and dot matrix printers (line printer graphics).
- Understand how color printers are controlled (changing their colors, etc.).
- Determine the approach to placing the color boxplots together to produce the complete plot. Spacing, choice of color, and graph features to be included were all considerations.

Each of these will be discussed in turn.

B. SIMTBED ARCHITECTURE.

SIMTBED, version 13, has 21 subroutines, including two added by this author to control the color dot matrix printers. Most of the subroutines are involved with computing statistics, regression, percentiles, and other numerical interests, and so are not of direct interest here. The starting subroutine, SIMTBED, calls the subroutine PRST once for each estimator being processed, and PRST is the routine that conducts the sectioning, calls the generator routines, obtains the statistics, and prepares the plots. This routine is where the color plotting preparation has to occur, although it will be printed in SIMTBED, since the color plot is not complete until all the estimators have been processed. PRST makes use of two important subroutines in constructing plots: BOXPRST, which puts a boxplot in a specified place in a plot array (given the appropriate statistics, of course), and NUMPRST, which puts an integer value into the plot array in the specified location. The color plotting routine will use both of these.

C. LINE PRINTER GRAPHICS.

Using character printing devices to generate plots is not a complicated concept. The line print (or dot matrix printer) is normally a character oriented device, and can be used

to create plots. The difficulty lies in determining the position of the points to be plotted. Once the position is determined, the appropriate character is simply printed. The approach to this method is to use a character matrix, a two-dimensional array of characters. The row is then the x axis, and the column is the y axis. Then, all the (x, y) pairs of points are scaled such that they run between zero and the dimension of the array. In SIMTBED, the dimensions are 132 spaces across and 50 vertical spaces. The dot matrix printer is used in compressed type mode, to make maximum use of the limited resolution it has compared to other graphic devices. For these purposes, line printer graphics work quite well.

The color plotting approach to line printer graphics uses the same approach, except there is a three dimensional character array: the first two dimensions represent the row and column of the plot, and the third dimension represents the color being plotted. Thus, there is one complete character array for each color to be plotted. When a character is to be plotted in a specified color, it is stored in that 'sheet' of the character array. Then, when printing is to occur, each line is printed the number of times corresponding to the number of colors before moving on to the next line.

D. COLOR PRINTERS.

I found that there is in fact a good degree of standardization in the commands used by different color printers. These commands consist of special escape code sequences to change the printer color (the escape character, the lower case 'r', and a numeric color code). This suggested a simple subroutine that would accept a number representing the color, and would set the printer (FORTRAN UNIT 6) to that color, using the escape code sequence. The other subroutine added merely initialized the three-dimensional color character array to all blanks.

E. DETERMINING THE COLOR PLOTTING.

Having determined the SIMTBED approach to line printer graphics, and the approach to the new color printers, it remained to choose a good way to display the color plots. How many subsample sizes? How should they be spaced? How much of the regression lines could be included before the plot became too cluttered? These issues were addressed through experimentation. Along the way, it was easily possible to increase the number of estimators SIMTBED could process from three to five. With five estimators, we found that more than three subsample sizes could result in twenty boxplots being plotted together in one plot. This was the limit. We restricted the number of subsample sizes for color combined boxplots to three, and with five estimators this proved to be

reasonable, if the subsample sizes are spread out. If they are not, but are closely arranged, then the scaling of the regression line, when plotted, will be incorrect. Because of this, and the clutter in the plot for different regression lines for different estimators, we removed the regression line from the color plots. The asymptote was kept, though, as it did not clutter the graphs terribly. This is the new current version of SIMTBED for the personal computer.

APPENDIX C. SAMPLE SIMTBED DRIVER ROUTINES

```

1 C      SIMTBED DRIVER FOR NORMAL AR(1) RANDOM VARIABLES                                RST
2 C      ----- SMTB12 ----- RST
3      REAL*4  Y(6500),YMIN, YMAX, V(8),RHO
4      CHARACTER*120 T1,T2,T3,T4,T5                                                    RST
5      REAL*8  IX1,IX2,IX3,IX4,IX5,IX
6      INTEGER N, M, NE(8), L, D, RG, SEI, SVS, NEST,NCOLRNDX(3)                      RST
7      EXTERNAL NAR3,NCRES1,NPRIES,NROBUS
8      REAL VMSE(8,5), VMX1(8,4),VMX2(8,4),VMX3(8,4),VMX4(8,4),VMX5(8,4) RST
9      COMMON RHO
10 C
11      DATA N/6000/
12      DATA M/ 20/
13      DATA NE/ 20,60,100,150,200,250,350,500/
14      DATA L/ 8/
15      DATA D/ 4/
16      DATA RG/ 1/
17      DATA SEI/ 0/
18      DATA SVS/ 0/
19      DATA YMIN/ 0./
20      DATA YMAX/ 0./
21      DATA IX/ 88771.DO/
22      DATA IFILE /1/
23      DATA NPRT /0/
24      DATA MSE /1/
25      DATA VMSE /32*.9,8*0/
26      DATA IPR /0/
27      DATA IBIV /0/
28      DATA IRSTR /1/
29      DATA T3/ '**Rho of N(0,4) r.v.s, rho=0.9 using moment estimator' /
30      DATA T2/ '**Rho of N(0,4) r.v.s, rho=0.9 using robust Least Squar
31      *es estimator' /
32      DATA T4/ '**Rho of N(0,4) r.v.s, rho=0.9 using Cressie estimator
33      C '/
34      DATA T5/ '**Rho of N(0,4) r.v.s, rho=0.9 using Priestly Estimator
35      */
36      DATA ICOLOR/1/ IBWPRT/1/ NCPRT/3/NCOLRNDX/1,2,7/
37      OPEN(06,FILE='NA1.OUT',ERR=999,IOSTAT=IER)
38      OPEN(05,FILE='CON ',ERR=999,IOSTAT=IER)
39      OPEN(02,FILE='NA1.RST',ERR=999,IOSTAT=IER,FORM='UNFORMATTED',
40      C ACCESS='SEQUENTIAL')
41      OPEN(01,FILE='NA1.DAT',ERR=999,IOSTAT=IER,FORM='FORMATTED',
42      C ACCESS='SEQUENTIAL')
43 C --- GENERATOR PARAMETERS
44      NEST=4
45      NSR=8
46      RHO=0.9
47 C
48      IX1=IX
49      IX2=IX
50      IX3=IX
51      IX4=IX

```

```

52      IX5=IX
53 C
54 C -----
55 C
56      CALL SIMTBED(IX1,IX2,IX3,IX4,IX5,Y,N,M,NE,L,D,NSR,RG,SEI,SVS,
57      * YMIN,YMAX,NEST,NROBUS,T2,NCRES1,T4,NAR3,T3,NPRIES,T5,NAR3,T3,
58      * IFILE
59      * ,NPRT,MSE,VMSE,IPR,VMX1,VMX2,VMX3,VMX4,VMX5,IBIV,IRSTR,ICOLOR,
60      * IBWPRT,NCPRT,NCOLRNDX)
61      STOP
62 C
63 999  CONTINUE
64      WRITE(6,*) '***** ERROR OPENING FILE 1, 2 or 6 '
65      END

```

RST

RST

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

66      INCLUDE 'AR1.FOR'
67      SUBROUTINE AR1(IX,X,N)
68 C THIS SUBROUTINE GENERATES THE NORMAL AR1 PROCESS, WITH CORR COEF
69 C RHO, MEAN 0, AND STDDEV 1
70      REAL*8 IX
71      REAL*4 X(*),RHO
72      COMMON RHO
73      CALL LNORPC(IX,X,N+1)
74      X(1)=RHO*X(N+1)/SQRT(1-RHO*RHO) + X(1)*SQRT(1-RHO*RHO)
75 C      WRITE(5,*)'X(1): ',X(1)
76      DO 100 I=2,N
77          X(I)=RHO*X(I-1) + X(I)*SQRT(1-RHO*RHO)
78 100  CONTINUE
79      RETURN
80      END

```

RST

RST

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

81      INCLUDE 'NAR3.FOR'
82      SUBROUTINE NAR3(IX,N,EVAL)
83 C LAG 1 SERIAL CORRELATION OF NORMAL (0,1) R.V.S , RHO=0.9
84 C USING XBAR TO ESTIMATE MU
85 C RHO OF THE AR1 PROCESS IS PASSED TO THE
86 C GENERATOR AR1 THROUGH COMMON STORAGE
87      REAL*8 IX
88      REAL*4 X(600),MEAN
89      COMMON RHO
90      CALL AR1(IX,X,N)
91      SUM=0
92      SUM1=0
93      DO 1 I=1,N
94 1    SUM=SUM+X(I)
95      MEAN=SUM/N
96      SUM=0
97      DO 2 I=2,N
98          SUM=SUM+(X(I)-MEAN)*(X(I-1)-MEAN)
99 2    SUM1=SUM1+(X(I)-MEAN)**2

```

```

100      EVAL=SUM/SUM1
101 C    WRITE(5,*)'SER. COR = ',EVAL
102      RETURN
103      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

104      INCLUDE 'NCRES1.FOR'
105      SUBROUTINE NCRES1(IX,N,EVAL)
106 C    COMPUTES THE LAG 1 CORR COEFF ESTIMATOR USING THE CRESSIE FORMULA
107 C    THE NORMAL AR1 PROCESS HAS RHO PASSED BY
108 C    COMMON STORAGE.
109 C    USES FUNCTION AMEDI TO GET THE
110 C    MEDIAN.
111      INTEGER N
112      REAL*8 IX
113      REAL*4 X(600),MEAN,MEDIAN
114      COMMON RHO
115      CALL AR1(IX,X,N)
116      SUM1=0
117      SUM2=0
118      MEDIAN=AMEDI(X,N)
119 C    WRITE(5,*)'MEDIAN = ',MEDIAN
120 C    WRITE(5,*)'X(I) ',(X(I),I=1,N)
121      DO 1 I=1,N-1
122      SUM1=SUM1+SQRT(ABS(X(I)-X(I+1)))
123 1     IF(ABS(X(I)-MEDIAN).GT.0)SUM2=SUM2+SQRT(ABS(X(I)-MEDIAN))
124      EVAL=1-(((SUM1/SUM2)**4)/2)
125 C    WRITE(5,*)'CRESS = ',EVAL
126      RETURN
127      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

128      FUNCTION AMEDI(X,N)
129 C    THIS ROUTINE USES A SHELLSORT AND INDEXES INTO THE REAL ARRAY X TO FIND
130 C    THE MEDIAN OF X WITHOUT REARRANGING IT.
131 C    THE INDEXES ARE USED AS INTEGER*2 TO CONSERVE STORAGE.
132      REAL*4 X(*)
133      INTEGER*2 I,INDX(600)
134      INTEGER N
135      DO 1 I=1,N
136 1     INDX(I)=I
137 C    WRITE(5,*)'UNSORTED LIST: ',(X(INDX(I)),I=1,N)
138      CALL SRTNDX(X,N,INDX)
139 C    WRITE(5,*)'SORTED LIST: ',(X(INDX(I)),I=1,N)
140      IF(MOD(N,2).EQ.0)THEN
141      AMEDI=(X(INDX(N/2))+X(INDX(N/2+1)))/2
142      ELSE
143      AMEDI=X(INDX(N/2+1))
144      ENDIF
145      RETURN
146      END

```

```

147      SUBROUTINE SRTNDX(Y,N,INDX)
148 C      INPLACE SORT USING SHELL ALGORITHM ***** SMT
149 C      USES INDEXES TO SORT BY TO PRESERVE ORIGINAL ORDER OF Y ARRAY
150      REAL Y(*)
151      INTEGER*2 GAP,INDX(*),ITEMP
152      INTEGER N
153      LOGICAL EXCH SMT
154 C SMT
155      GAP=(N/2) SMT
156 5      IF (.NOT.(GAP.NE.0)) GO TO 500 SMT
157 10      CONTINUE SMT
158          EXCH=.TRUE. SMT
159          K=N-GAP SMT
160          DO 200 I=1,K SMT
161              KK=I+GAP SMT
162              IF(.NOT.(Y(INDX(I)).GT.Y(INDX(KK)))) GO TO 100
163                  ITEMP=INDX(I)
164                  INDX(I)=INDX(KK)
165                  INDX(KK)=ITEMP
166                  EXCH=.FALSE.
167 100          CONTINUE
168 200          CONTINUE SMT
169              IF (.NOT.(EXCH)) GO TO 10 SMT
170              GAP=(GAP/2) SMT
171          GO TO 5 SMT
172 500      CONTINUE SMT
173          RETURN SMT
174          END SMT

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

175      INCLUDE 'NPRIES.FOR'
176      SUBROUTINE NPRIES(IX,N,EVAL)
177 C    COMPUTES THE LAG 1 CORR COEFF ESTIMATOR USING THE PRIESTLY FORMULA
178 C    THE NORMAL AR1 PROCESS HAS RHO PASSED BY
179 C    COMMON STORAGE.
180      REAL*8 IX
181      REAL*4 X(600),MEAN,A,B,XBAR1,XBAR2,MUHAT,
182      *SUM1,SUM2
183      COMMON RHO
184      CALL AR1(IX,X,N)
185      A=0
186      B=0
187      XBAR1=0
188      XBAR2=0
189      SUM1=0
190      SUM2=0
191      DO 1 I=1,N-1
192      A=A+X(I)*X(I)
193      B=B+X(I)*X(I+1)
194      XBAR1=XBAR1+X(I)
195 1    XBAR2=XBAR2+X(I+1)

```

```

196 C    WRITE(5,*)'I: ',I,' X(I)',X(I),'A: ',A,'B: ',B,'XBAR1: ',XBAR1,'XBA
197 C    *R2: ',XBAR2
198      XBAR1=XBAR1/(N-1)
199      XBAR2=XBAR2/(N-1)
200      MUHAT=(A*XBAR2-B*XBAR1)/((A-B)+((N-1)*XBAR1*(XBAR2-XBAR1)))
201      DO 2 I=1,N-1
202        SUM1=SUM1+(X(I)-MUHAT)*(X(I+1)-MUHAT)
203 2     SUM2=SUM2+(X(I)-MUHAT)**2
204      EVAL=SUM1/SUM2
205 C    WRITE(5,*)'SUM1: ',SUM1,'SUM2: ',SUM2
206 C    WRITE(5,*)'PREISTLY MUHAT',MUHAT
207 C    WRITE(5,*)'XBAR1: ',XBAR1,'XBAR2: ',XBAR2
208 C    WRITE(5,*)'A: ',A,'B: ',B,'N: ',N
209 C    WRITE(5,*)'X>>>>',(X(I),I=1,N)
210 C    WRITE(5,*)'PRIESTLY RHO: ',EVAL
211      RETURN
212      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

213      INCLUDE 'NROBUS.FOR'
214      SUBROUTINE NROBUS(SEED,N,EVAL)
215 C    THIS ROUTINE GENERATES A STREAM OF R. V. S, AND THEN PERFORMS ROBUST
216 C    REGRESSION ON THEM TO ESTIMATE RHO.
217 C    THE CURRENT STREAM IS AR(1) NORMAL R. V. S.
218      REAL*8 SEED
219      REAL*4 X(600),Y(600),B(1),XX(1,1),XXI(1,1),XY(1,1)
220      REAL*4 RMED1,RMED2,RMED3,SR1,SR2,SR3,SY,CR,W(600),U(600)
221      REAL*4 WX(600,1),WY(600),EVAL
222      INTEGER N,I,IN
223      COMMON RHO
224      DATA CY/1.0/CR/4.2/CY/1.0/
225      DATA NN/1/IPAS/5/
226      IX2=1
227      CALL AR1(SEED,X,N)
228 C    CONSTRUCT X AND Y VECTORS FROM X ARRAY
229      DO 1 I=1,N-1
230 1     Y(I)=X(I+1)
231      IN=N-1
232      IX1=IN
233      CALL ROBREG(X,Y,B,IN,NN,IX1,IX2,CR,XX,XXI,XY,W,U,WX,WY,IPAS)
234      EVAL=B(1)
235 C    WRITE(5,*)'EVAL: ',EVAL
236      RETURN
237      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

238      SUBROUTINE ROBREG(X,Y,B,M,N,IX1,IX2,C,XX,XXI,XY,W,U,WX,WY,IPAS)
239 C    ROBUST REGRESSION ON Y=X*B RRE
240 C    IPAS=MAX # REGRESSION PASSES. 1 FOR STD (I.E. NON-ROBUST) REGRESSION RRE
241 C    X=M BY N MATRIX CONTAINED IN AN ARRAY OF DIM(IX1,IX2) RRE
242 C    Y=M-VECTOR CONTAINED IN AN ARRAY OF DIM(IX1) RRE
243 C    B=N-VECTOR CONTAINED IN AN ARRAY OF DIM(IX2) RRE

```

```

244 C XX,XXI=WORK ARRAYS OF DIM(IX2,IX2) RRE
245 C W,U,WY=WORK ARRAYS OF DIM(IX1) RRE
246 C WX=WORK MATRIX OF DIM(IX1,IX2) RRE
247 C XY=WORK ARRAY OF DIM(IX2) RRE
248 C WK=WORK ARRAY OF DIM(N**2 + 3*N) OR LARGER RRE
249 C C=CONSTANT. USUALLY = 6. RRE
250 C CRITERION FOR STOPPING IS WHEN VARIATION IN CONST.TERM < 1% RRE
251 C IT USES SEVERAL SUBROUTINES FROM IMSL FOR MATRIX INVERSION, RRE
252 C MULTIPLICATION, ETC. ALSO USES PXSORT TO SORT ARRAY. RRE
253 REAL*4 X(IX1,IX2),XX(IX2,IX2),XXI(IX2,IX2)
254 REAL*4 Y(IX1),WK(600)
255 REAL*4 B(IX2),W(IX1),XY(IX2),BB,WX(IX1,IX2),WY(IX1)
256 REAL*4 U(IX1),C,S,AM,R,SS,SUM1
257 NPAS=0 RRE
258 ZERO=0 RRE
259 C SUPPRESS ERROR MESSAGES: UNDERFLOW AND IMSL RRE
260 C CALL ERRSET(208,300,-1,1) RRE
261 C CALL UERSET(0,LEVOLD) RRE
262 AM=(M+1.)/2. RRE
263 IM=AM RRE
264 R=AM-IM RRE
265 B(1)=-999999. RRE
266 DO 5 I=1,M RRE
267 WY(I)=Y(I) RRE
268 DO 6 J=1,N RRE
269 WX(I,J)=X(I,J) RRE
270 6 CONTINUE RRE
271 5 CONTINUE RRE
272 C RRE
273 10 CONTINUE RRE
274 NPAS=NPAS+1 RRE
275 C CALL VMULFM(WX,WX,M,N,N,IX1,IX1,XX,IX2,IER) RRE
276 C VMULFM PERFORMS X TRANSPOSE X. WE CAN DO IT WITH A DO LOOP, SINCE
277 C IN THIS CASE X IS A VECTOR. RESULT GOES IN XX (DIM 1,1)
278
279 XX(1,1)=0
280 DO 200 I=1,M
281 200 XX(1,1)=XX(1,1)+WX(I,1)**2
282 IER=0
283 C IF (IER.GT.0) WRITE (6,109) IER RRE
284 109 FORMAT('ERROR:',2I10) RRE
285 C CALL VMULFM(WX,WY,M,N,1,IX1,IX1,XY,IX2,IER) RRE
286 C VMULFM PERFORMS MATRIX MULTIPLICATION. WE WILL DO IT WITH A DO LOOP
287 C SINCE X AND Y ARE VECTORS. RESULT GOES IN XY (DIM 1,1).
288 XY(1)=0
289 DO 201 I=1,M
290 201 XY(1)=XY(1)+WX(I,1)*WY(I)
291 IER=0
292 C IF (IER.GT.0) WRITE (6,109) IER RRE
293 C CALL LINV2F(XX,N,IX2,XXI,ZERO,WK,IER) RRE
294 C LINV2F FINDS THE INVERSE OF A MATRIX (X TRANSPOSE X). WE WILL DO IT
295 C WITH A DO LOOP, SINCE X IS A VECTOR IN THIS CASE. RESULT INTO XXI.
296
297 XXI(1,1)=1/XX(1,1)
298
299 C IF (IER.GT.0) WRITE (6,109) IER RRE

```

```

300      BB=B(1)
301 C      CALL VMULFF(XXI,XY,N,N,1,IX2,IX2,B,IX2,IER)
302 C      PERFORMING X TRANSPOSE X INVERSE TIMES X TRANSPOSE Y.  RESULT INTO
303 C B (DIM 1).  DONE WITHOUT A SUB CALL IN THIS CASE, SINCE WE'RE
304 C DEALING WITH VECTORS.
305      B(1)=XY(1)*XXI(1,1)
306
307
308 C      IF (IER.GT.0) WRITE (6,109) IER
309 C      WRITE(6,101)(B(I),I=1,N)
310 101  FORMAT(5F20.10)
311      IF(NPAS .GE. IPAS) GO TO 99
312      IF (ABS(B(1)-BB) .LT. .01*ABS(BB)) GO TO 99
313 C      CALL VMULFF(X,B,M,N,1,IX1,IX2,W,IX1,IER)
314 C YHAT COMES FROM X TIMES B, DONE WITH A DO LOOP SINCE WE HAVE VECTORS.
315      DO 202 I=1,M
316 202  W(I)=X(I,1)*B(1)
317
318 C      IF (IER.GT.0) WRITE (6,109) IER
319 C      COMPUTE RESIDUALS AND MEDIAN OF ABSOLUTE RESIDUALS
320      DO 20 I=1,M
321      W(I)=Y(I)-W(I)
322 20  U(I)=ABS(W(I))
323      CALL PKSORT(U,1,M)
324 C      WRITE(6, 499) (U(I),I=1,M)
325 499  FORMAT(6F20.10)
326 105  FORMAT(8F10.7)
327      S=U(IM) + R*(U(IM+1)-U(IM))
328      S=C*C*S*S
329      SS=S*.5
330 C      WRITE(6,199) SS
331 199  FORMAT('      CS: ',F20.10)
332      DO 40 I=1,M
333      W(I)=W(I)*W(I)/S
334      IF (W(I) .LT. 1.) GO TO 25
335 C      FACTOR IS 0. IN THIS CASE
336      WY(I)=0.
337      DO 31 J=1,N
338      WX(I,J)=0.
339 31  CONTINUE
340      GO TO 40
341 25  W(I)=(1-W(I))
342      DO 35 J=1,N
343 35  WX(I,J)=X(I,J)*W(I)
344      WY(I)=Y(I)*W(I)
345 40  CONTINUE
346      GO TO 10
347 99  CONTINUE
348      RETURN
349      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

350 C
351 C      SUBROUTINE PKSORT (M1)

```


352 C		PXS
353 C	PURPOSE	PXS
354 C		PXS
355 C	SUBROUTINE PXSORT IS INTENDED TO REARRANGE AN ARRAY OF REAL*4	PXS
356 C	DATA INTO ASCENDING ORDER BETWEEN TWO SPECIFIED INDICES.	PXS
357 C		PXS
358 C	CALLING SEQUENCE	PXS
359 C		PXS
360 C	CALL PXSORT(A, II, JJ)	PXS
361 C		PXS
362 C	ARGUMENTS	PXS
363 C		PXS
364 C	A A SINGLE DIMENSIONED ARRAY OF REAL*4 DATA TO BE	PXS
365 C	SORTED INTO ASCENDING ORDER. DIMENSIONED TO AT LEAST JJ.	PXS
366 C		PXS
367 C	II THE STARTING INDEX FOR THE ORDERING OF A,	PXS
368 C	E.G., II=1 IF THE WHOLE ARRAY IS TO BE SORTED.	PXS
369 C		PXS
370 C	JJ THE ENDING INDEX FOR ORDERING A.	PXS
371 C		PXS
372 C	USAGE	PXS
373 C		PXS
374 C	THE ARRAY A WILL BE SORTED INTO INCREASING ORDER SO THAT	PXS
375 C	A(I) < A(I+1) FOR I = II,II+1,...,JJ-2,JJ-1.	PXS
376 C		PXS
377 C	PXSORT WILL ONLY SORT REAL*4 DATA, NOT REAL*8, INTEGER, OR	PXS
378 C	ALPHANUMERIC DATA.	PXS
379 C		PXS
380 C	SUBROUTINES REQUIRED	PXS
381 C		PXS
382 C	NONE.	PXS
383 C		PXS
384 C	METHOD	PXS
385 C		PXS
386 C	SINGLETON'S VERSION OF THE PARTITION EXCHANGE SORT IS	PXS
387 C	USED. THE PROGRAM IS ESSENTIALLY COPIED FROM THE ASSOCIATION	PXS
388 C	FOR COMPUTING MACHINERY'S ALGORITHM 247, "SORTING WITH	PXS
389 C	MINIMAL STORAGE."	PXS
390 C		PXS
391 C	PROGRAMMER: IMPLEMENTED AT NPS BY D.W. ROBINSON	PXS
392 C		PXS
393 C	DATE: APR 74	PXS
394 C		PXS
395 C	-----	PXS
396 C		PXS
397 C	SUBROUTINE PXSORT(A,II,JJ)	PXS
398 C		PXS
399 C	DIMENSION A(JJ),IU(16),IL(16)	PXS
400 C	M=1	PXS
401 C	I=II	PXS
402 C	J=JJ	PXS
403 C	5 IF(I .GE. J)GO TO 70	PXS
404 C	10 K=I	PXS
405 C	IJ=(I+J)/2	PXS
406 C	T=A(IJ)	PXS
407 C	IF(A(I) .LE. T) GO TO 20	PXS

408	A(IJ)=A(I)	PXS
409	A(I)=T	PXS
410	T=A(IJ)	PXS
411	20 L=J	PXS
412	IF(A(J) .GE. T) GO TO 40	PXS
413	A(IJ)=A(J)	PXS
414	A(J)=T	PXS
415	T=A(IJ)	PXS
416	IF(A(I) .LE. T) GO TO 40	PXS
417	A(IJ)=A(I)	PXS
418	A(I)=T	PXS
419	T=A(IJ)	PXS
420	GO TO 40	PXS
421	30 TT = A(L)	PXS
422	A(L) = A(K)	PXS
423	A(K)=TT	PXS
424	40 L=L-1	PXS
425	IF(A(L) .GT. T) GO TO 40	PXS
426	50 K=K+1	PXS
427	IF(A(K) .LT. T) GO TO 50	PXS
428	IF(K .LE. L) GO TO 30	PXS
429	IF(L-I .LE. J-K) GO TO 60	PXS
430	IL(M)=I	PXS
431	IU(M)=L	PXS
432	I=K	PXS
433	M=M+1	PXS
434	GO TO 80	PXS
435	60 IL(M)=K	PXS
436	IU(M)=J	PXS
437	J=L	PXS
438	M=M+1	PXS
439	GO TO 80	PXS
440	70 M=M-1	PXS
441	IF(M .EQ. 0) RETURN	PXS
442	I=IL(M)	PXS
443	J=IU(M)	PXS
444	80 IF(J-I .GE. 11)GO TO 10	PXS
445	IF(I .EQ. II) GO TO 5	PXS
446	I=I-1	PXS
447	90 I=I+1	PXS
448	IF(I .EQ. J) GO TO 70	PXS
449	IF(A(I) .LE. A(I+1)) GO TO 90	PXS
450	T = A(I+1)	PXS
451	K=I	PXS
452	100 A(K+1)=A(K)	PXS
453	K=K-1	PXS
454	IF(T .LT. A(K)) GO TO 100	PXS
455	A(K+1)=T	PXS
456	GO TO 90	PXS
457	END	PXS

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
 NUMBER OF ERRORS IN PROGRAM UNIT: 0
 NUMBER OF WARNINGS IN COMPILATION : 0
 NUMBER OF ERRORS IN COMPILATION : 0

```

1 C      SIMTBED DRIVER FOR BETA-L-LAPLACE TRANSFORM AR PROCESS          RST
2 C      ----- SMTB12 ----- RST
3      REAL*4  Y(6500),YMIN, YMAX, V(8),RHO,LL,ALPHA
4      CHARACTER*120 T1,T2,T3,T4,T5          RST
5      REAL*8  IX1,IX2,IX3,IX4,IX5,IX
6      INTEGER N, M, NE(8), L, D, RG, SEI, SVS, NEST,NCOLRNDX(3)      RST
7      EXTERNAL BMOM,BCRES1,BBBB,ROBUST
8      REAL VMSE(8,5), VMX1(8,4),VMX2(8,4),VMX3(8,4),VMX4(8,4),VMX5(8,4) RST
9      COMMON ALPHA,LL
10 C                                           RST
11      DATA  N/6000/
12      DATA  M/ 20/
13      DATA  NE/ 20,60,100,150,200,250,350,500/
14      DATA  L/ 8/
15      DATA  D/ 4/
16      DATA  RG/ 1/
17      DATA  SEI/ 0/
18      DATA  SVS/ 0/
19      DATA  YMIN/ 0./
20      DATA  YMAX/ 0./
21      DATA  IX/ 88771.DO/
22      DATA  IFILE /1/
23      DATA  NPRT  /1/
24      DATA  MSE   /1/
25      DATA  VMSE  /32*0.8963,8*0/
26      DATA  IPR   /0/
27      DATA  IBIV  /0/
28      DATA  IRSTR /1/
29      DATA  T2/ '***Rho(.8963) of SqrtBeta L laplace AR r.v.s, A=.84, L=
30      * .95 Using Robust Least Squares estimator (C=4.2)'/
31      DATA  T3/ '***Rho(.8963) of SqrtBeta L laplace AR r.v.s, A=.84, L=
32      * .95 Using moment estimator'/
33      DATA  T4/ '***Rho(.8963) of SqrtBeta L laplace AR r.v.s., A=.84, L=
34      * .95 Using Cressie Estimator'/
35      DATA  T5/ '***Rho(.8963) of SqrtBeta L laplace AR r.v.s., A=.84, L=
36      * .95 Using Priestly Estimator'/
37      DATA  ICOLOR/1/ IBWPRT/1/ NCPRT/3/NCOLRNDX/1,2,7/
38      OPEN(06,FILE='bf1.OUT',ERR=999,IOSTAT=IER)
39      OPEN(05,FILE='CON ',ERR=999,IOSTAT=IER)
40      OPEN(02,FILE='bf1.RST',ERR=999,IOSTAT=IER,FORM='UNFORMATTED',
41      C ACCESS='SEQUENTIAL')
42      OPEN(01,FILE='Bf1.DAT',FORM='FORMATTED',ACCESS='SEQUENTIAL')
43 C --- GENERATOR PARAMETERS          RST
44      NEST=4
45      NSR=3
46      LL= .95
47      ALPHA=0.84
48 C                                           RST
49      IX1=IX          RST
50      IX2=IX          RST
51      IX3=IX          RST
52      IX4=IX          RST
53      IX5=IX
54 C

```

```

55 C ----- RST
56 C
57 CALL SIMTBED(IX1,IX2,IX3,IX4,IX5,Y,N,M,NE,L,D,NSR,RG,SEI,SVS,
58 * YMIN,YMAX,NEST,robust,t2,BCRES1,T4,BMOM,T3,BBBB,T5,BMOM,T3,IFILE
59 * ,NPRT,MSE,VMSE,IPR,VMX1,VMX2,VMX3,VMX4,VMX5,IBIV,IRSTR,ICOLOR,
60 * IBWPRT,NCPRT,NCOLRNDX)
61 STOP
62 C
63 999 CONTINUE
64 WRITE(6,*) '***** ERROR OPENING FILE 1, 2 or 6 '
65 END RST

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

66 INCLUDE 'BELAR1.for'
67 SUBROUTINE BELAR1(SEED,ALPHA,L,N,X)
68 C THIS SUBROUTINE GENERATES CORRELATED L LAPLACE R.V.S USING THE
69 C BETA SQUARE ROOT TRANSFORMATION AND THE L LAPLACE DISTRIBUTION
70 C THE L LAPLACE DISTRIBUTION IS GENERATED AS THE DIFFERENCE OF
71 C 2 GAMMA(L,1) RANDOM VARIABLES.
72 REAL*8 SEED
73 REAL*4 ALPHA,L,X(*),Y(5100),A(5100),B(5100),E,F
74 INTEGER N
75 C FIRST GENERATE THE L LAPLACE STREAM OF R.V.S
76 C THIS WAS FOR USING IMSL SSTAT18A RANDOM NUMBER GENERATORS
77 C CALL RNSET(12345678)
78 CALL LGAMPC(SEED,X,N,L)
79 CALL LGAMPC(SEED,Y,N,L)
80 DO 10 I=1,N
81 10 Y(I)=X(I)-Y(I)
82 C NOW GENERATE THE BETA R.V.S (2 STREAMS)
83
84 CALL LBETPC(SEED,A,N,L*ALPHA,L*(1-ALPHA))
85 CALL LBETPC(SEED,B,N,L*(1-ALPHA),L*ALPHA)
86 C WRITE(5,*)(A(I),I=1,N)
87 C WRITE(5,*)(B(I),I=1,N)
88
89 C A(I) IS NOW BETA(L*ALPHA,L*(1-ALPHA))
90 C B(I) IS NOW BETA(L*(1-ALPHA),L*ALPHA)
91 X(1)=Y(1)
92 DO 12 I=2,N
93 C WRITE(5,50)'A',A(I),'B',B(I),'I',I
94 50 FORMAT(' ',A,E15.6,A,E15.6,A,I4)
95 C CHECK FOR UNDERFLOW BEFORE SQRT IS DONE
96 IF(A(I).LE.1E-7) THEN
97 C WRITE(5,*)'A(I)',A(I)
98 A(I)=1E-7
99 E=A(I)**0.5
100 ELSE
101 C WRITE(5,*)'ROOTING A...',I
102 E=A(I)**0.5
103 ENDIF
104 IF(B(I).LE.1E-7) THEN
105 C WRITE(5,*)'B(I)',B(I)
106 B(I)=1E-7

```

```

107      F=B(I)**0.5
108      ELSE
109 C    WRITE(5,*)'ROOTING B...',I
110      F=B(I)**0.5
111      ENDIF
112
113 C    A MINUS SIGN AT THE START OF LINE 12 INDICATES WE ARE CONTSTRUCTING
114 C    NEGATIVE CORRELATIONS.
115
116 12    X(I)=-X(I-1)*E+Y(I)*F
117      RETURN
118      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

119      INCLUDE 'BMOM.for'
120      SUBROUTINE BMOM(IX,N,EVAL)
121 C    LAG 1 SERIAL CORRELATION OF BETA L LAPLACE R.V.S , RHO=0.7996
122 C    USING XBAR TO ESTIMATE MU
123 C    L AND ALPHA OF THE BETA AR PROCESS ARE PASSED TO THE
124 C    GENERATOR BELAR1 THROUGH COMMON STORAGE
125      REAL*8 IX
126      REAL*4 X(600),MEAN,ALPHA,L
127      COMMON ALPHA,L
128      CALL BELAR1(IX,ALPHA,L,N,X)
129      SUM=0
130      SUM1=0
131      DO 1 I=1,N
132 1    SUM=SUM+X(I)
133      MEAN=SUM/N
134      SUM=0
135      DO 2 I=2,N
136      SUM=SUM+(X(I)-MEAN)*(X(I-1)-MEAN)
137 2    SUM1=SUM1+(X(I)-MEAN)**2
138      EVAL=SUM/SUM1
139 C    WRITE(5,*)'SER. COR = ',EVAL
140      RETURN
141      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

142      INCLUDE 'BBBB.for'
143      SUBROUTINE BBBB(IX,N,EVAL)
144 C    COMPUTES THE LAG 1 CORR COEFF ESTIMATOR USING THE PRIESTLY FORMULA
145 C    THE BETA LAPLACE PROCESS HAS ALPHA AND L PASSED BY
146 C    COMMON STORAGE.
147      REAL*8 IX
148      REAL*4 X(600),MEAN,MEANINPU,STDINPU,A,B,XBAR1,XBAR2,MUHAT
149      REAL SUM1,SUM2,ALPHA,L
150      COMMON ALPHA,L
151 C    WRITE(5,*)'ENTERED BPRIES N: ',N,I,ALPHA
152      CALL BELAR1(IX,ALPHA,L,N,X)
153      A=0
154      B=0

```

```

155      XBAR1=0
156      XBAR2=0
157      SUM1=0
158      SUM2=0
159      DO 1 I=1,N-1
160      A=A+X(I)*X(I)
161      B=B+X(I)*X(I+1)
162      XBAR1=XBAR1+X(I)
163 1     XBAR2=XBAR2+X(I+1)
164 C     WRITE(5,*)'I: ',I,' X(I)',X(I),'A: ',A,'B: ',B,'XBAR1: ',XBAR1,'XBA
165 C     *R2: ',XBAR2
166      XBAR1=XBAR1/(N-1)
167      XBAR2=XBAR2/(N-1)
168      MUHAT=(A*XBAR2-B*XBAR1)/((A-B)+((N-1)*XBAR1*(XBAR2-XBAR1)))
169      DO 2 I=1,N-1
170      SUM1=SUM1+(X(I)-MUHAT)*(X(I+1)-MUHAT)
171 2     SUM2=SUM2+(X(I)-MUHAT)**2
172      EVAL=SUM1/SUM2
173 C     WRITE(5,*)'SUM1: ',SUM1,'SUM2: ',SUM2
174 C     WRITE(5,*)'PREISTLY MUHAT',MUHAT
175 C     WRITE(5,*)'XBAR1: ',XBAR1,'XBAR2: ',XBAR2
176 C     WRITE(5,*)'A: ',A,'B: ',B,'N: ',N
177 C     WRITE(5,*)'X>>>>',(X(I),I=1,N)
178 C     WRITE(5,*)'PRIESTLY RHO: ',EVAL
179      RETURN
180      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

181      INCLUDE 'ROBUST.for'
182      SUBROUTINE ROBUST(SEED,N,EVAL)
183 C THIS ROUTINE GENERATES A STREAM OF R.V.S, AND THEN PERFORMS ROBUST
184 C REGRESSION ON THEM TO ESTIMATE RHO.
185 C THE CURRENT STREAM IS AR(1) NORMAL R.V.S.
186      REAL*8 SEED
187      REAL*4 X(600),Y(600),B(1),XX(1,1),XXI(1,1),XY(1,1)
188      REAL*4 RMED1,RMED2,RMED3,SR1,SR2,SR3,SY,CR,W(600),U(600)
189      REAL*4 WX(600,1),WY(600),EVAL
190      INTEGER N,I,IN
191      COMMON ALPHA,L
192      DATA CY/1.0/CR/4.2/CY/1.0/
193      DATA NN/1/IPAS/5/
194      IX2=1
195      CALL BELAR1(SEED,ALPHA,L,N,X)
196 C CONSTRUCT X AND Y VECTORS FROM X ARRAY
197      DO 1 I=1,N-1
198 1     Y(I)=X(I+1)
199      IN=N-1
200      IX1=IN
201      CALL ROBREG(X,Y,B,IN,NN,IX1,IX2,CR,XX,XXI,XY,W,U,WX,WY,IPAS)
202      EVAL=B(1)
203 C     WRITE(5,*)'EVAL: ',EVAL
204      RETURN
205      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

206      SUBROUTINE ROBREG(X,Y,B,M,N,IX1,IX2,C,XX,XXI,XY,W,U,WX,WY,IPAS)
207 C    ROBUST REGRESSION ON Y=X*B                                RRE
208 C    IPAS=MAX # REGRESSION PASSES. 1 FOR STD (I.E. NON-ROBUST) REGRESSION RRE
209 C    X=M BY N MATRIX CONTAINED IN AN ARRAY OF DIM(IX1,IX2)      RRE
210 C    Y=M-VECTOR CONTAINED IN AN ARRAY OF DIM(IX1)              RRE
211 C    B=N-VECTOR CONTAINED IN AN ARRAY OF DIM(IX2)              RRE
212 C    XX,XXI=WORK ARRAYS OF DIM(IX2,IX2)                        RRE
213 C    W,U,WY=WORK ARRAYS OF DIM(IX1)                            RRE
214 C    WX=WORK MATRIX OF DIM(IX1,IX2)                            RRE
215 C    XY=WORK ARRAY OF DIM(IX2)                                 RRE
216 C    WK=WORK ARRAY OF DIM(N**2 + 3*N)      OR LARGER           RRE
217 C    C=CONSTANT. USUALLY = 6.                                  RRE
218
219
220
221
222 C    CRITERION FOR STOPPING IS WHEN VARIATION IN CONST.TERM < 1% RRE
223 C    IT USES SEVERAL SUBROUTINES FROM IMSL FOR MATRIX INVERSION, RRE
224 C    MULTIPLICATION, ETC. ALSO USES PXSORT TO SORT ARRAY.      RRE
225      REAL*4 X(IX1,IX2),XX(IX2,IX2),XXI(IX2,IX2)
226      REAL*4 Y(IX1),WK(600)
227      REAL*4 B(IX2),W(IX1),XY(IX2),BB,WX(IX1,IX2),WY(IX1)
228      REAL*4 U(IX1),C,S,AM,R,SS,SUM1
229      NPAS=0                                                    RRE
230      ZERO=0                                                    RRE
231 C    SUPPRESS ERROR MESSAGES: UNDERFLOW AND IMSL              RRE
232 C    CALL ERRSET(208,300,-1,1)                                  RRE
233 C    CALL UERSET(0,LEVOLD)                                       RRE
234      AM=(M+1.)/2.                                              RRE
235      IM=AM                                                       RRE
236      R=AM-IM                                                     RRE
237      B(1)=-999999.                                              RRE
238      DO 5 I=1,M                                                  RRE
239        WY(I)=Y(I)                                               RRE
240        DO 6 J=1,N                                                RRE
241          WX(I,J)=X(I,J)                                          RRE
242      6 CONTINUE                                                  RRE
243      5 CONTINUE                                                  RRE
244 C                                                                RRE
245      10 CONTINUE                                                 RRE
246      NPAS=NPAS+1                                                 RRE
247 C    CALL VMULFM(WX,WX,M,N,N,IX1,IX1,XX,IX2,IER)              RRE
248 C    VMULFM PERFORMS X TRANSPOSE X. WE CAN DO IT WITH A DO LOOP, SINCE
249 C    IN THIS CASE X IS A VECTOR.  RESULT GOES IN XX (DIM 1,1)
250
251      XX(1,1)=0
252      DO 200 I=1,M
253 200    XX(1,1)=XX(1,1)+WX(I,1)**2
254      IER=0
255 C    IF (IER.GT.0) WRITE (6,109) IER                                RRE
256 109 FORMAT('ERROR:',2I10)                                       RRE
257 C    CALL VMULFM(WX,WY,M,N,1,IX1,IX1,XY,IX2,IER)              RRE
258 C    VMULFM PERFORMS MATRIX MULTIPLICATION.  WE WILL DO IT WITH A DO LOOP

```

```

259 C SINCE X AND Y ARE VECTORS. RESULT GOES IN XY (DIM 1,1).
260     XY(1)=0
261     DO 201 I=1,M
262 201   XY(1)=XY(1)+WX(I,1)*WY(I)
263     IER=0
264 C     IF (IER.GT.0) WRITE (6,109) IER
265 C     CALL LINV2F(XX,N,IX2,XXI,ZERO,WK,IER)
266 C     LINV2F FINDS THE INVERSE OF A MATRIX (X TRANSPOSE X). WE WILL DO IT
267 C     WITH A DO LOOP, SINCE X IS A VECTOR IN THIS CASE. RESULT INTO XXI.
268
269     XXI(1,1)=1/XX(1,1)
270
271 C     IF (IER.GT.0) WRITE (6,109) IER
272     BB=B(1)
273 C     CALL VMULFF(XXI,XY,N,N,1,IX2,IX2,B,IX2,IER)
274 C     PERFORMING X TRANSPOSE X INVERSE TIMES X TRANSPOSE Y. RESULT INTO
275 C     B (DIM 1). DONE WITHOUT A SUB CALL IN THIS CASE, SINCE WE'RE
276 C     DEALING WITH VECTORS.
277     B(1)=XY(1)*XXI(1,1)
278
279
280 C     IF (IER.GT.0) WRITE (6,109) IER
281 C     WRITE(6,101)(B(I),I=1,N)
282 101  FORMAT(5F20.10)
283     IF(NPAS .GE. IPAS) GO TO 99
284     IF (ABS(B(1)-BB) .LT. .01*ABS(BB)) GO TO 99
285 C     CALL VMULFF(X,B,M,N,1,IX1,IX2,W,IX1,IER)
286 C     YHAT COMES FROM X TIMES B, DONE WITH A DO LOOP SINCE WE HAVE VECTORS.
287     DO 202 I=1,M
288 202   W(I)=X(I,1)*B(1)
289
290 C     IF (IER.GT.0) WRITE (6,109) IER
291 C     COMPUTE RESIDUALS AND MEDIAN OF ABSOLUTE RESIDUALS
292     DO 20 I=1,M
293     W(I)=Y(I)-W(I)
294 20  U(I)=ABS(W(I))
295     CALL PXSORT(U,1,M)
296 C     WRITE(6, 499) (U(I),I=1,M)
297 499  FORMAT(6F20.10)
298 105  FORMAT(8F10.7)
299     S=U(IM) + R*(U(IM+1)-U(IM))
300     S=C*C*S*S
301     IF(S.LT.1E-07) THEN
302 c     WRITE(5,*)'S: IN ROBREG: ',S,'(SET 1 1E-07) U(IM)',U(IM),'R',
303 c     *      R
304         S=1.E-07
305         ss=1.e-14
306     ELSE
307         SS=S**.5
308     ENDIF
309 199  FORMAT('      CS: ',F20.10)
310     DO 40 I=1,M
311     W(I)=W(I)*W(I)/S
312     IF (W(I) .LT. 1.) GO TO 25
313 C     FACTOR IS 0. IN THIS CASE
314     WY(I)=0.

```


315	DO 31 J=1,N	RRE
316	WX(I,J)=0.	RRE
317	31 CONTINUE	RRE
318	GO TO 40	RRE
319	25 W(I)=(1-W(I))	RRE
320	DO 35 J=1,N	RRE
321	35 WX(I,J)=X(I,J)*W(I)	RRE
322	WY(I)=Y(I)*W(I)	RRE
323	40 CONTINUE	RRE
324	GO TO 10	RRE
325	99 CONTINUE	RRE
326	RETURN	RRE
327	END	RRE

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

328 C		PXS
329 C	SUBROUTINE PXSORT (M1)	PXS
330 C		PXS
331 C	PURPOSE	PXS
332 C		PXS
333 C	SUBROUTINE PXSORT IS INTENDED TO REARRANGE AN ARRAY OF REAL*4	PXS
334 C	DATA INTO ASCENDING ORDER BETWEEN TWO SPECIFIED INDICES.	PXS
335 C		PXS
336 C	CALLING SEQUENCE	PXS
337 C		PXS
338 C	CALL PXSORT(A, II, JJ)	PXS
339 C		PXS
340 C	ARGUMENTS	PXS
341 C		PXS
342 C	A A SINGLE DIMENSIONED ARRAY OF REAL*4 DATA TO BE	PXS
343 C	SORTED INTO ASCENDING ORDER. DIMENSIONED TO AT LEAST JJ.	PXS
344 C		PXS
345 C	II THE STARTING INDEX FOR THE ORDERING OF A,	PXS
346 C	E.G., II=1 IF THE WHOLE ARRAY IS TO BE SORTED.	PXS
347 C		PXS
348 C	JJ THE ENDING INDEX FOR ORDERING A.	PXS
349 C		PXS
350 C	USAGE	PXS
351 C		PXS
352 C	THE ARRAY A WILL BE SORTED INTO INCREASING ORDER SO THAT	PXS
353 C	A(I) < A(I+1) FOR I = II,II+1,...,JJ-2,JJ-1.	PXS
354 C		PXS
355 C	PXSORT WILL ONLY SORT REAL*4 DATA, NOT REAL*8, INTEGER, OR	PXS
356 C	ALPHANUMERIC DATA.	PXS
357 C		PXS
358 C	SUBROUTINES REQUIRED	PXS
359 C		PXS
360 C	NONE.	PXS
361 C		PXS
362 C	METHOD	PXS
363 C		PXS
364 C	SINGLETON'S VERSION OF THE PARTITION EXCHANGE SORT IS	PXS
365 C	USED. THE PROGRAM IS ESSENTIALLY COPIED FROM THE ASSOCIATION	PXS
366 C	FOR COMPUTING MACHINERY'S ALGORITHM 247, "SORTING WITH	PXS

367 C	MINIMAL STORAGE."	PXS
368 C		PXS
369 C	PROGRAMMER: IMPLEMENTED AT NPS BY D.W. ROBINSON	PXS
370 C		PXS
371 C	DATE: APR 74	PXS
372 C		PXS
373 C	-----	PXS
374 C		PXS
375	SUBROUTINE PXSORT(A,II,JJ)	PXS
376 C		PXS
377	DIMENSION A(JJ),IU(16),IL(16)	PXS
378	M=1	PXS
379	I=II	PXS
380	J=JJ	PXS
381	5 IF(I .GE. J)GO TO 70	PXS
382	10 K=I	PXS
383	IJ=(I+J)/2	PXS
384	T=A(IJ)	PXS
385	IF(A(I) .LE. T) GO TO 20	PXS
386	A(IJ)=A(I)	PXS
387	A(I)=T	PXS
388	T=A(IJ)	PXS
389	20 L=J	PXS
390	IF(A(J) .GE. T) GO TO 40	PXS
391	A(IJ)=A(J)	PXS
392	A(J)=T	PXS
393	T=A(IJ)	PXS
394	IF(A(I) .LE. T) GO TO 40	PXS
395	A(IJ)=A(I)	PXS
396	A(I)=T	PXS
397	T=A(IJ)	PXS
398	GO TO 40	PXS
399	30 TT = A(L)	PXS
400	A(L) = A(K)	PXS
401	A(K)=TT	PXS
402	40 L=L-1	PXS
403	IF(A(L) .GT. T) GO TO 40	PXS
404	50 K=K+1	PXS
405	IF(A(K) .LT. T) GO TO 50	PXS
406	IF(K .LE. L) GO TO 30	PXS
407	IF(L-I .LE. J-K) GO TO 60	PXS
408	IL(M)=I	PXS
409	IU(M)=L	PXS
410	I=K	PXS
411	M=M+1	PXS
412	GO TO 80	PXS
413	60 IL(M)=K	PXS
414	IU(M)=J	PXS
415	J=L	PXS
416	M=M+1	PXS
417	GO TO 80	PXS
418	70 M=M-1	PXS
419	IF(M .EQ. 0) RETURN	PXS
420	I=IL(M)	PXS
421	J=IU(M)	PXS
422	80 IF(J-I .GE. 11)GO TO 10	PXS

423	IF(I .EQ. II) GO TO 5	PXS
424	I=I-1	PXS
425	90 I=I+1	PXS
426	IF(I .EQ. J) GO TO 70	PXS
427	IF(A(I) .LE. A(I+1)) GO TO 90	PXS
428	T = A(I+1)	PXS
429	K=I	PXS
430	100 A(K+1)=A(K)	PXS
431	K=K-1	PXS
432	IF(T .LT. A(K)) GO TO 100	PXS
433	A(K+1)=T	PXS
434	GO TO 90	PXS
435	END	PXS

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

436      INCLUDE 'BCRES1.for'
437      SUBROUTINE BCRES1(IX,N,EVAL)
438 C    COMPUTES THE LAG 1 CORR COEFF ESTIMATOR USING THE CRESSIE FORMULA
439 C    THE BETA LAPLACE PROCESS HAS ALPHA AND LPASSED BY
440 C    COMMON STORAGE.
441 C    USES FUNCTION AMEDI (WHICH USES HEAPSORT AND HEAPIFY) TO GET THE
442 C    MEDIAN.
443      REAL*8 IX
444      REAL*4 X(600),MEAN,MEANINPU,MEDIAN,STDINPU,ALPHA,L
445      COMMON ALPHA,L
446      CALL BELAR1(IX,ALPHA,L,N,X)
447      SUM1=0
448      SUM2=0
449      MEDIAN=AMEDI(X,N)
450 C    WRITE(5,*)'MEDIAN = ',MEDIAN
451 C    WRITE(5,*)'X(I) ',(X(I),I=1,N)
452      DO 1 I=1,N-1
453      SUM1=SUM1+SQRT(ABS(X(I)-X(I+1)))
454 1     IF(ABS(X(I)-MEDIAN).GT.0)SUM2=SUM2+SQRT(ABS(X(I)-MEDIAN))
455      EVAL=1-(((SUM1/SUM2)**4)/2)
456 C    WRITE(5,*)'CRESS = ',EVAL
457      RETURN
458      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

459      FUNCTION AMEDI(X,N)
460 C    THIS ROUTINE USES A SHELLSORT AND INDEXES INTO THE REAL ARRAY X TO FIND
461 C    THE MEDIAN OF X WITHOUT REARRANGING IT.
462 C    THE INDEXES ARE USED AS INTEGER*2 TO CONSERVE STORAGE.
463      REAL*4 X(*)
464      INTEGER*2 I,INDX(600)
465      INTEGER N
466      DO 1 I=1,N
467 1     INDX(I)=I
468 C    WRITE(5,*)'UNSORTED LIST: ',(X(INDX(I)),I=1,N)
469      CALL SRTNDX(X,N,INDX)
470 C    WRITE(5,*)'SORTED LIST: ',(X(INDX(I)),I=1,N)

```

```

471      IF(MOD(N,2).EQ.0)THEN
472          AMEDI=(X(INDX(N/2))+X(INDX(N/2+1)))/2
473      ELSE
474          AMEDI=X(INDX(N/2+1))
475      ENDIF
476      RETURN
477      END

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0

```

478      SUBROUTINE SRTNDX(Y,N,INDX)
479 C      INPLACE SORT USING SHELL ALGORITHM ***** SMT
480 C      USES INDEXES TO SORT BY TO PRESERVE ORIGINAL ORDER OF Y ARRAY
481          REAL Y(*)
482          INTEGER*2 GAP,INDX(*),ITEMP
483          INTEGER N
484          LOGICAL EXCH SMT
485 C SMT
486          GAP=(N/2) SMT
487      5 IF (.NOT.(GAP.NE.0)) GO TO 500 SMT
488      10 CONTINUE SMT
489          EXCH=.TRUE. SMT
490          K=N-GAP SMT
491          DO 200 I=1,K SMT
492              KK=I+GAP SMT
493              IF(.NOT.(Y(INDX(I)).GT.Y(INDX(KK)))) GO TO 100
494                  ITEMP=INDX(I)
495                  INDX(I)=INDX(KK)
496                  INDX(KK)=ITEMP
497                  EXCH=.FALSE.
498      100 CONTINUE
499      200 CONTINUE SMT
500          IF (.NOT.(EXCH)) GO TO 10 SMT
501              GAP=(GAP/2) SMT
502          GO TO 5 SMT
503      500 CONTINUE SMT
504          RETURN SMT
505          END SMT

```

NUMBER OF WARNINGS IN PROGRAM UNIT: 0
NUMBER OF ERRORS IN PROGRAM UNIT: 0
NUMBER OF WARNINGS IN COMPILATION : 0
NUMBER OF ERRORS IN COMPILATION : 0

APPENDIX D. SMTBED SOURCE CODE (VERSION 13)

Source File: SMTB13.FOR

Options: /b /l /x

07/18/88 20:50:28

```

1 C   UPDATED 05-10-84 BY LCU TO ADD SERIAL CORRELATION          SMT
2 C   UPDATED 07-16-84 BY LCU TO MULTIPLE RUN AND SUMMARY STATISTICS PAGE SMT
3 C   UPDATED 07-30-84 BY LCU TO ADD NORMALIZED QUANTILES        SMT
4 C   UPDATED 10-25-84 BY LCU TO CONVERT TO FORTRAN 77           SMT
5 C   UPDATED 08-12-85 BY LCU TO ALLOW DEGREE REGRESSION UP TO 6 ON VAR. SMT
6 C   UPDATED 04-04-86 BY LCU TO SAVE STATS. FROM EACH SUPER REPL. ON FILE SMT
7 C   UPDATED 05-12-86 BY LCU TO COMPUTE MEAN SQUARE ERROR        SMT
8 C   UPDATED 09-09-86 BY LCU TO DO PERCENTILE PLOTS             SMT
9 C   UPDATED 09-29-86 BY LCU TO DO BIVARIATE HISTOGRAMS. BUG FIX 02-09-87 SMT
10 C  UPDATED 06-10-87 BY LCU TO ADD RESTART FEATURE             SMT
11 C  UPDATE 12/87 BY RLY FOR COLOR PRINTER SUPPORT OF COMBINED BOXPLOTS
12 C  UPDATE 4/88 BY RLY FOR 5 ESTIMATORS
13 C
14 C  PURPOSE      TO GENERATE REGRESSION ADJUSTED ESTIMATES AND BOX PLOTS SMT
15 C                OF ESTIMATES OF AN INPUT RAW DATA SERIES X CONTAINING M SMT
16 C                (REPLICATIONS) OF N VALUES EACH. UP TO 3 ESTIMATING SMT
17 C                FUNCTIONS CAN BE USED. THE GRAPHS CAN ALL BE OF THE SAME SMT
18 C                SCALE OR SCALED INDIVIDUALLY.                  SMT
19 C  *            THE SERIES X IS GENERATED FROM INSIDE SIMTB BY USER SMT
20 C  *            PROVIDED FUNCTION                                SMT
21 C
22 C  DESCRIPTION OF PARAMETERS                                     SMT
23 C
24 C  *  GEST1, GEST2, GEST3,GEST4,GEST5:                          SMT
25 C      USER SUBROUTINES THAT WILL GENERATE THE DATA,SMT00220
26 C  *      AND THEN COMPUTE AN ESTIMATE FROM IT.                  SMT
27 C  *      THE ACTUAL NAMES USED NAMES MUST BE DECLARED AS EXTERNAL SMT
28 C  *      IN THE CALLING PROGRAM. CALLS MUST BE AS FOLLOWS:    SMT
29 C  *      CALL SUBROUTINE_NAME(IX,NX,EVAL)                       SMT
30 C  *      WHERE:                                                 SMT
31 C  *      IX=SEED (INPUT AND OUTPUT ARGUMENT)                   SMT
32 C  *      NX=NO. OF DATA POINTS TO TO GENERATE                 SMT
33 C  *      EVAL=VALUE OF ESTIMATOR APPLIED TO THE NX DATA POINTS SMT
34 C  *      NOTICE THAT PROGRAM ASSUMES THREE SUBROUTINES IN THE SMT
35 C  *      ARGUMENTS. WHEN USING LESS THAN 3 ESTIMATORS FILL THE SMT
36 C  *      ARGUMENT POSITIONS WITH DUMMY VARIABLES OR JUST REPEAT SMT
37 C  *      THE LAST ONE.                                          SMT
38 C
39 C  *  ISEED1, ISEED2, ISEED3,ISEED4, ISEED5:                    SMT
40 C      SEEDS FOR DATA GENERATORS 1, 2 & 3.                     SMT
41 C  *      THE SEEDS ARE UPDATED (ADVANCED) UPON RETURN FROM SIMTB SMT
42 C
43 C  *  Y          WORK ARRAY OF SIZE >= M*N/NE(1))                SMT
44 C
45 C  N          NUMBER OF DATA ELEMENTS PER SECTION (N IS SAMPLE SIZE). SMT
46 C
47 C  M          NUMBER OF SECTIONS (REPLICATIONS).                 SMT
48 C      M CANNOT EXCEED 100                                       SMT
49 C

```

50 C	NE	INTEGER ARRAY OF SIZE 8 CONTAINING SUBSAMPLE SIZES FOR N.	SMT
51 C		THE VALUES OF NE MUST BE FROM SMALLEST TO LARGEST.	SMT
52 C		NO ELEMENT OF THE ARRAY NE CAN BE GREATER THAN N.	SMT
53 C			SMT
54 C	L	NUMBER OF SUBSAMPLE SIZES FROM NE(8) THAT WILL BE USED TO	SMT
55 C		SECTION N. MUST BE BETWEEN 2 AND 8.	SMT
56 C		IT IS ALSO THE NUMBER OF BOXPLOTS THAT WILL BE PRODUCED.	SMT
57 C			SMT
58 C	D	DEGREE OF REGRESSION FOR MEAN AND VARIANCE REGRESSIONS.	SMT
59 C		D WILL BE REDUCED BY SIMTB IF THE SAMPLE IS NOT LARGE	SMT
60 C		ENOUGH. D MUST BE 1 TO 6. D=0 WILL IGNORE REGRESSIONS.	SMT
61 C			SMT
62 C	NSR	NO. OF RUNS TO REPEAT SIMTB (>=1) WITH A PAGE OF	SMT
63 C		SUMMARY STATISTICS AT THE END WHEN >1.	SMT
64 C			SMT
65 C		*** SCALING ***	SMT
66 C		SCALING IS ACCOMPLISHED BY TAKING THE SMALLEST AND THE	SMT
67 C		LARGEST ESTIMATE VALUES FROM ALL ESTIMATING FUNCTIONS	SMT
68 C		EVALUATED ON THE SHORTEST SECTION LENGTH (NE(1)).	SMT
69 C		THE SEI PARAMETER ALLOWS THE USER TO SCALE THE GRAPHS	SMT
70 C		OF EACH ESTIMATOR INDIVIDUALLY OR TO SCALE THEM ALL TO	SMT
71 C		THE SAME SCALE. SCALING ALL TO THE SAME SCALE IS	SMT
72 C		ACCOMPLISHED BY TAKING THE MINIMUM AND MAXIMUM ESTIMATES	SMT
73 C		FROM ALL THE ESTIMATORS USING NE(1) SUBSAMPLE SIZE.	SMT
74 C		THE RG PARAMETER ALLOWS THE USER TO REDUCE THE VER-	SMT
75 C		TICAL SCALE TO; THE UPPER QUARTILE DISTANCE + 1.5 TIMES	SMT
76 C		INTERQUARTILE DISTANCE AS THE MAX VALUE AND THE LOWER	SMT
77 C		QUARTILE - 1.5 TIMES THE INTERQUARTILE DISTANCE AS THE	SMT
78 C		MIN VALUE. THE INTERQUARTILE DISTANCE IS COMPUTED FROM	SMT
79 C		THE SAMPLE OF ESTIMATES FROM THE NE(1) SUBSAMPLE SIZE.	SMT
80 C		IF THERE ARE NO ESTIMATES OUTSIDE THESE MIN AND MAX	SMT
81 C		VALUES THEN THE SCALE IS TO THE FIRST VALUE WITHIN.	SMT
82 C		IF THERE ARE ESTIMATES OUTSIDE THESE LIMITS THEN THEY	SMT
83 C		ARE COUNTED AND THE NUMBER PRINTED AT THE ENDS OF THE	SMT
84 C		BOX PLOTS.	SMT
85 C		THE SVS PARAMETER ALLOWS THE USER TO SET THE VERTICAL	SMT
86 C		SCALE. WHEN THE VERTICAL SCALE IS SET THE SEI PARAMETER	SMT
87 C		IS IGNORED AND THE VERTICAL SCALE BECOMES YMIN AND YMAX.	SMT
88 C			SMT
89 C			SMT
90 C	RG	RG=0 DO NOT REDUCE THE VERTICAL SCALE OF THE GRAPHS.	SMT
91 C		RG=1 REDUCE GRAPHICS VERTICAL SCALE TO UPPER (LOWER)	SMT
92 C		QUARTILE + (-) INTERQUARTILE DISTANCE.	SMT
93 C			SMT
94 C	SEI	SEI=0 DO NOT SCALE ESTIMATORS' GRAPHS INDIVIDUALLY.	SMT
95 C		SEI=1 SCALE ESTIMATORS' GRAPHS INDIVIDUALLY.	SMT
96 C			SMT
97 C	SVS	SVS=0 PROGRAM WILL CALCULATE VERTICAL SCALE.	SMT
98 C		SVS=1 USER SETS VERTICAL SCALE TO YMIN AND YMAX.	SMT
99 C			SMT
100 C	YMIN	LOW VALUE OF VERTICAL SCALE. SET BY USER WHEN SVS=1	SMT
101 C			SMT
102 C	YMAX	HIGH VALUE OF VERTICAL SCALE. SET BY USER WHEN SVS=1	SMT
103 C			SMT
104 C	NEST	NUMBER OF ESTIMATORS THAT WILL BE USED TO CALCULATE	SMT
105 C		STATISTICAL PARAMETER FROM X DATA.	SMT

106 C		NEST MUST BE 1,2,3,4 OR 5.	
107 C			SMT
108 C	TTL1	TITLES ASSOCIATED WITH EACH ESTIMATOR (1 THRU 5). A MAX	SMT
109 C	TTL2	OF 120 CHARACTERS CAN BE USED TO DESCRIBE EACH ESTIMATOR.	SMT
110 C	TTL3	EACH TITLE MUST BE DECLARED AS CHARACTER*120 STRINGS	SMT
111 C	TTL4		
112 C	TTL5		
113 C			SMT
114 C	IFIL	0 - DO NOT RECORD STATS. FROM EACH SUPER REPL. ON FILE	SMT
115 C		1 - RECORD STATISTICS ON FILE UNIT 1 FOR FURTHER PROCESSINGS	SMT
116 C		UNIT 1 FILE IS SEQUENTIAL, FORMATTED. THE DATA PLACED	SMT
117 C		IN THE FILE INCLUDES LABELS	SMT
118 C			SMT
119 C	NPRT	0 - PRINT DETAIL FOR UP TO 3 SUPER REPLICATIONS	SMT
120 C		AND PRINT NORMALIZED QUANTILE PLOTS (STANDARD SETTING)	SMT
121 C		1 - PRINT ONLY 1 SUPER REPL. AND NO NORMALIZED QUANTILE	SMT
122 C			SMT
123 C	MSE	0 - DO NOT PRINT MEAN SQUARED ERRORS USING VMSE MATRIX	SMT
124 C		1 - PRINT MEAN SQUARED ERRORS WITH VMSE MATRIX	SMT
125 C			SMT
126 C	VMSE	MATRIX 8X5 WITH KNOWN MEANS ON EACH COL. FOR EACH ESTIMATORS	SMT
127 C			SMT
128 C	IPR	0 - DO NOT PRINT PERCENTILE PLOTS	SMT
129 C		1 - PRINT PERCENTILE PLOTS	SMT
130 C			SMT
131 C	VMX1	3 MATRICES 8X4 EACH WITH VALUES FOR PERCENTILE PLOTS	SMT
132 C	VMX2	EACH REPRESENTING 8 VALUES FOR EACH SECTION SIZE	SMT
133 C	VMX3	(IF L<8 PAD WITH ZEROES). 4 SUCH SETS MUST BE ENTERED	SMT
134 C	VMX4	FOR EACH MATRIX	SMT
135 C	VMX5		
136 C			SMT
137 C	IBIV	0 - DO NOT PRINT BIVARIATE HISTOGRAMS	SMT
138 C		1 - PRINT BIVARIATE HISTOGRAMS	SMT
139 C			SMT
140 C	RSTRT	0 - THIS IS NOT A RESTART RUN.	SMT
141 C		1 - THIS IS A RESTART RUN. AT THE END SAVE RESTART	SMT
142 C		VALUES ON UNIT 2. AT THE BEGINNING READ UNIT 2	SMT
143 C		AND CONTINUE EXECUTION AT THE SUPER-REPLICATION	SMT
144 C		WHERE IT WAS LEFT OFF. IF NO FILE EXISTS FOR	SMT
145 C		FOR UNIT 2 IT WILL ASSUME THIS IS THE FIRST RUN.	SMT
146 C		UNIT 2 SHOULD BE OPENED BY THE CALLING PROGRAM IF	SMT
147 C		A DIFFERENT NAME OF THE FORTRAN DEFAULT IS TO BE	SMT
148 C		USED. ON VM/CMS A FILEDEF WILL DO THE SAME.	SMT
149 C			SMT
150 C		THE RESTART FILE IS TYPE SEQUENTIAL UNFORMATTED, AND	SMT
151 C		CAN ONLY BE READ BY A FORTRAN PROGRAM. USE UNIT 2	SMT
152 C		FOR STATISTICS FILE. DEFAULT UNFORMATTED RECORD	SMT
153 C		LENGTH OF 1024 BYTES IS ADEQUATE.	
154 C			SMT
155 C	ICOLOR	0 - NO COLOR PRINTOUT	
156 C		1 - PRINT COLOR COMBINATION OF ESTIMATORS FOR THE	
157 C		ESTIMATORS FOR UP TO THREE SAMPLE SIZES (NEED AT	
158 C		LEAST 2 TO MAKE SENSE). THIS IS IN ADDITION TO	
159 C		THE REGULAR PRINTOUTS, WHICH ARE FLAGGED SEPARATELY.	
160 C			
161 C	IBWPRT	0 - DO NOT PRINT THE STANDARD PRINTOUTS.	

```

162 C          1 - PRINT THE STANDARD PRINTOUTS.
163 C
164 C
165 C          NOTE:  IF BOTH ICOLOR AND IBWPRT ARE ZERO, NO PRINTOUTS
166 C                   OCCUR.
167 C
168 C          NCPRT - NUMBER OF SAMPLE SIZES FOR WHICH TO PRINT COLOR BOXPLOT
169 C                   COMBINATIONS.  MUST BE 1,2, OR 3.
170 C
171 C          NCOLRNDX( ) - ARRAY INDEX TO NE(*); USE THESE SAMPLE SIZES FOR COLOR
172 C                   BOXPLOTS
173 C
174 C
175 C
176 C*****SMT
177 C                   SMT
178 C          SUBROUTINE SMTBED( ISEED1, ISEED2, ISEED3, ISEED4, ISEED5,
179 C          * Y, N, M, NE, L, D, NSR, RG, SEI, SVS, YMIN, YMAX, NEST, GEST1, TTL1, GEST2, TTL2,
180 C          * GEST3, TTL3, GEST4, TTL4, GEST5, TTL5, IFIL, NPRT,
181 C          * MSE, VMSE, IPR, VMX1, VMX2, VMX3, VMX4, VMX5,
182 C          * IBIV, RSTRT, ICOLOR, IBWPRT, NCPRT, NCOLRNDX)
183 C          PARAMETER (NBROWS=500)
184 C          real*8 ISEED1, ISEED2, ISEED3, ISEED4, ISEED5, ISEED
185 C          CHARACTER*1 COLRPLT(122,50,5), COLRXIS(122,2), BLK
186 C          CHARACTER*120 TTL1, TTL2, TTL3, TTL4, TTL5
187 C          CHARACTER*8 LABEL(7)
188 C          REAL Y(1), GV(2), VMSE(8,5), BA(7), BS(7), BV(7), V(7)
189 C          REAL VMX1(8,4), VMX2(8,4), VMX3(8,4), COLRSTAT(8,7,5)
190 C          REAL VMX4(8,4), VMX5(8,4)
191 C          REAL BIV1(NBROWS,8), BIV2(NBROWS,8), BIV3(NBROWS,8), BIV4(NBROWS,8)
192 C          REAL TX(NBROWS), TY(NBROWS), DLH(4)
193 C          INTEGER NE(8), RG, SEI, SVS, SM, IFIL
194 C          INTEGER D, L, NEST, TEST, IBPTR(8)
195 C          INTEGER RSTRT, NNE(8), NCOLRNDX(3)
196 C          REAL VYMAX(5), VYMIN(5)
197 C          REAL*8 GST1(8,7,2), GPV1(8,11,2)
198 C          REAL*8 GST2(8,7,2), GPV2(8,11,2)
199 C          REAL*8 GST3(8,7,2), GPV3(8,11,2)
200 C          REAL*8 GST4(8,7,2), GPV4(8,11,2)
201 C          REAL*8 GST5(8,7,2), GPV5(8,11,2)
202 C          REAL*8 GBA1(7,2), GBV1(7,2), GBS1(7,2), GVV1(7,2)
203 C          REAL*8 GBA2(7,2), GBV2(7,2), GBS2(7,2), GVV2(7,2)
204 C          REAL*8 GBA3(7,2), GBV3(7,2), GBS3(7,2), GVV3(7,2)
205 C          REAL*8 GBA4(7,2), GBV4(7,2), GBS4(7,2), GVV4(7,2)
206 C          REAL*8 GBA5(7,2), GBV5(7,2), GBS5(7,2), GVV5(7,2)
207 C          DATA GST1/112*0.D0/, GPV1/176*0.D0/
208 C          DATA GST2/112*0.D0/, GPV2/176*0.D0/
209 C          DATA GST3/112*0.D0/, GPV3/176*0.D0/
210 C          DATA GST4/112*0.D0/, GPV4/176*0.D0/
211 C          DATA GST5/112*0.D0/, GPV5/176*0.D0/
212 C          DATA GBA1/14*0.D0/, GBV1/14*0.D0/, GBS1/14*0.D0/, GVV1/14*0.D0/
213 C          DATA GBA2/14*0.D0/, GBV2/14*0.D0/, GBS2/14*0.D0/, GVV2/14*0.D0/
214 C          DATA GBA3/14*0.D0/, GBV3/14*0.D0/, GBS3/14*0.D0/, GVV3/14*0.D0/
215 C          DATA GBA4/14*0.D0/, GBV4/14*0.D0/, GBS4/14*0.D0/, GVV4/14*0.D0/
216 C          DATA GBA5/14*0.D0/, GBV5/14*0.D0/, GBS5/14*0.D0/, GVV5/14*0.D0/
217 C          DATA BLK/' '/

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218 C
219 C --- SAVE BASIC RUN PARAMETERS & TITLES ON STATISTICS FILE SMT
220 IF(IFIL.EQ. 1)WRITE(1,560)N,M,NE,L,D,NSR,NEST,TTL1,TTL2,TTL3, SMT
221 *TTL4,TTL5
222 560 FORMAT('SAMPLE SIZE: ',I10,'REPLICATIONS: ',I10,
223 * '/'SUBSAMPLE SIZES: '/8I10/'L = ',I10,'DEGREE REG: ',I10,'SUPER
224 *-REPS: ',I10,'/NO. ESTIM.: ',I10,'/5(A120/))
225 C SMT
226 C --- DETERMINE CASE OF RESTART. IRST=0 NO RESTART SMT
227 C IRST=1 IS 1ST RUN (SAVE VALUFS AT END) SMT
228 C IRST=2 IS CONTINUATION OF PREVIOUS RUN SMT
229 INSR=1 SMT
230 WRITE(5,555)
231 555 format(' SMTBED - A Simulation Test Bed (Version 13.0, April 1988)
232 * '/' (PC version).... START OF RUN')
233 C IF THERE IS ONLY ONE ESTIMATOR, CAN'T COMBINE FOR COLOR OUTPUT
234 IF(NEST.EQ.1)ICOLOR=0
235 IRST=RSTRT SMT
236 IF(RSTRT.EQ. 0) GO TO 9004 SMT
237 REWIND 2 SMT
238 READ(2,END=9003) NN,MM,NNE,LL,IDD,NNSR,NNEST,NSEI, SMT
239 * ISEED1,ISEED2,ISEED3, ISEED4,ISEED5,VYMIN,VYMAX SMT
240 IF(NN.NE.N .OR. MM.NE.M .OR. LL.NE.L .OR. IDD.NE.D .OR. SMT
241 * NSR.LE.NNSR .OR. NSEI.NE.SEI .OR. NNEST.NE.NEST) GO TO 9002 SMT
242 DO 9001 I=1,8 SMT
243 IF(NNE(I).NE.NE(I)) GO TO 9002 SMT
244 9001 CONTINUE SMT
245 IRST=2 SMT
246 C
247 C THESE READ STATEMENTS ARE BROKEN UP SO THE DEFAULT UNFORMATTED
248 C RECORD LENGTH WILL HOLD THE DATA, AND THE USER DOESN'T HAVE TO
249 C WORRY WITH RUNTIME PARAMETERS ON HIS COMPILED PROGRAM
250 C
251 READ(2,END=9006)((GPV1(I,J,1),I=1,8),J=1,11)
252 READ(2,END=9006)((GPV1(I,J,2),I=1,8),J=1,11)
253 READ(2,END=9006)GST1
254 READ(2,END=9006)GBA1,GBV1,GBS1,GVV1 SMT
255
256 IF(NEST .GE. 2) THEN
257 READ(2,END=9006)((GPV2(I,J,1),I=1,8),J=1,11)
258 READ(2,END=9006)((GPV2(I,J,2),I=1,8),J=1,11)
259 READ(2,END=9006)GST2
260 READ(2,END=9006)GBA2,GBV2,GBS2,GVV2 SMT
261 ENDIF
262 IF(NEST .GE. 3) THEN
263 READ(2,END=9006)((GPV3(I,J,1),I=1,8),J=1,11)
264 READ(2,END=9006)((GPV3(I,J,2),I=1,8),J=1,11)
265 READ(2,END=9006)GST3
266 READ(2,END=9006)GBA3,GBV3,GBS3,GVV3 SMT
267 ENDIF
268 IF(NEST .GE. 4) THEN
269 READ(2,END=9006)((GPV4(I,J,1),I=1,8),J=1,11)
270 READ(2,END=9006)((GPV4(I,J,2),I=1,8),J=1,11)
271 READ(2,END=9006)GST4
272 READ(2,END=9006)GBA4,GBV4,GBS4,GVV4 SMT
273 ENDIF

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274      IF(NEST .GE. 5) THEN
275          READ(2,END=9006)((GPV5(I,J,1),I=1,8),J=1,11)
276          READ(2,END=9006)((GPV5(I,J,2),I=1,8),J=1,11)
277          READ(2,END=9006)GST5
278          READ(2,END=9006)GBA5,GBV5,GBS5,GVV5
279      ENDIF
280 C --- FIX VERTICAL SCALE TO USE YMIN,YMAX COMPUTED IN PREVIOUS RUN
281      SVS=1
282 C --- START SUPER-REPLICATIONS COUNT FOLLOWING WHERE LEFT OFF
283      INSR=NNSR+1
284      GO TO 50
285 9002 CONTINUE
286 C --- ERROR IN A RESTART RUN. NEW PARMS NOT COMPATIBLE WITH OLD ONES
287      WRITE(5,*) 'ARGUMENTS FOR RESTART DO NOT AGREE WITH VALUES ',
288      * 'FOUND ON FILE UNIT 2. THEY ARE: '
289      WRITE(5,*) 'N,M,L,D,NSR,NEST,SEI=',NN,MM,LL,IDD,NNSR,NNEST,NSEI
290      WRITE(5,*) 'NE: ', (NNE(I), I=1,LL)
291      STOP
292 C --- TABLES NOT PRESENT FOR ALL ESTIMATORS
293 9006 CONTINUE
294      WRITE(5,*) ' *** ERROR: RESTART FILE DOES NOT HAVE TABLES FOR',
295      * ' ALL ESTIMATORS'
296      STOP
297 C
298 9003 CONTINUE
299 C --- RESTART FILE NOT EXISTENT. ASSUME 1ST RUN
300      IRST=1
301 9004 CONTINUE
302 C
303 C SET SEI TO 0 FOR NO INDIVIDUAL SCALING IF WE ARE DOING COLOR PLOTS
304 C
305      IF(ICOLOR.EQ.1)SEI=0
306 C
307      IF(SVS.EQ.1) THEN
308          DO 9011 I=1,5
309              VYMAX(I)=YMAX
310              VYMIN(I)=YMIN
311 9011 CONTINUE
312      ENDIF
313      SM=NE(1)
314      MN = M*N
315      LT=L-1
316      IF(LT.EQ.0) GO TO 13
317      DO 11 I=1,LT
318          I1=I+1
319          IF(NE(I).GT.NE(I1))WRITE(6,110)
320 11 CONTINUE
321 13 TEST=0
322      IF(NEST.EQ.1 .OR. NEST.EQ.2 .OR. NEST.EQ.3 .OR. NEST.EQ.4 .OR.
323      * NEST.EQ.5) GO TO 2
324      WRITE(5,106)
325      TEST=1
326 2 IF(M.GE.1.AND.M.LE.100) GO TO 3
327      WRITE(5,104)
328      TEST=1
329 3 IF(L.GE.1.AND.L.LE.8) GO TO 4

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330	WRITE(5,103)	SMT
331	TEST=1	SMT
332 4	IF(D.LE.6) GO TO 5	SMT
333	WRITE(5,108)	SMT
334	TEST=1	SMT
335 5	CONTINUE	SMT
336	IF(NE(L) .LT. N) GO TO 6	SMT
337	WRITE(5,107)	SMT
338	TEST=1	SMT
339 6	CONTINUE	SMT
340	IF(NSR .GE. 1) GO TO 7	SMT
341	WRITE(5,111)	SMT
342	TEST=1	SMT
343 7	CONTINUE	SMT
344	IF (TEST.NE.0) GO TO 8001	SMT
345 C		SMT
346 C	BYPASS SCALE CALCULATION WHEN FIXED	SMT
347	IF (SVS .EQ. 1) GO TO 50	SMT
348 C	*****	SMT
349 C	* COMPUTE SCALE FOR EACH ESTIMATOR	SMT
350 C	*****	SMT
351	ISEED=ISEED1	SMT
352	DO 10 IK=1,1	SMT
353 C	FIND VERTICAL SCALE FOR 1ST ESTIMATOR.	SMT
354	CALL SECEST(GEST1,ISEED,N,M,NE(IK),Y,KP)	SMT
355	IF(RG.EQ.1) CALL DELETO(Y,KP,VYMAX(1),VYMIN(1))	SMT
356	IF(RG.NE.1) CALL MAXMIN(Y,KP,VYMAX(1),VYMIN(1))	SMT
357	YMIN=VYMIN(1)	SMT
358	YMAX=VYMAX(1)	SMT
359	10 CONTINUE	SMT
360 C		SMT
361 C	FIND VERTICAL SCALE FOR 2ND ESTIMATOR.	SMT
362	IF(NEST .LT. 2) GO TO 40	SMT
363	ISEED=ISEED2	SMT
364	DO 20 IK=1,1	SMT
365	CALL SECEST(GEST2,ISEED,N,M,NE(IK),Y,KP)	SMT
366	IF(RG.EQ.1) CALL DELETO(Y,KP,VYMAX(2),VYMIN(2))	SMT
367	IF(RG.NE.1) CALL MAXMIN(Y,KP,VYMAX(2),VYMIN(2))	SMT
368	YMIN=AMIN1(YMIN, VYMIN(2))	SMT
369	YMAX=AMAX1(YMAX, VYMAX(2))	SMT
370	20 CONTINUE	SMT
371 C		SMT
372 C	FIND VERTICAL SCALE FOR 3RD ESTIMATOR.	SMT
373	IF(NEST .LT. 3) GO TO 40	SMT
374	ISEED=ISEED3	SMT
375	DO 30 IK=1,1	SMT
376	CALL SECEST(GEST3,ISEED,N,M,NE(IK),Y,KP)	SMT
377	IF(RG.EQ.1) CALL DELETO(Y,KP,VYMAX(3),VYMIN(3))	SMT
378	IF(RG.NE.1) CALL MAXMIN(Y,KP,VYMAX(3),VYMIN(3))	SMT
379	YMIN=AMIN1(YMIN, VYMIN(3))	SMT
380	YMAX=AMAX1(YMAX, VYMAX(3))	SMT
381	30 CONTINUE	SMT
382 C		SMT
383 C	FIND VERTICAL SCALE FOR 4TH ESTIMATOR.	SMT
384	IF(NEST .LT. 4) GO TO 40	SMT
385	ISEED=ISEED4	SMT

386	DO 31 IK=1,1	SMT
387	CALL SECEST(GEST4, ISEED, N, M, NE(IK), Y, KP)	SMT
388	IF(RG.EQ. 1) CALL DELETO(Y, KP, VYMAX(4), VYMIN(4))	SMT
389	IF(RG.NE. 1) CALL MAXMIN(Y, KP, VYMAX(4), VYMIN(4))	SMT
390	YMIN=AMIN1(YMIN, VYMIN(4))	SMT
391	YMAX=AMAX1(YMAX, VYMAX(4))	SMT
392	31 CONTINUE	SMT
393 C		
394 C	FIND VERTICAL SCALE FOR 5TH ESTIMATOR.	SMT
395	IF(NEST .LT. 5) GO TO 40	SMT
396	ISEED=ISEED5	SMT
397	DO 32 IK=1,1	SMT
398	CALL SECEST(GEST5, ISEED, N, M, NE(IK), Y, KP)	SMT
399	IF(RG.EQ. 1) CALL DELETO(Y, KP, VYMAX(5), VYMIN(5))	SMT
400	IF(RG.NE. 1) CALL MAXMIN(Y, KP, VYMAX(5), VYMIN(5))	SMT
401	YMIN=AMIN1(YMIN, VYMIN(5))	SMT
402	YMAX=AMAX1(YMAX, VYMAX(5))	SMT
403	32 CONTINUE	SMT
404	40 CONTINUE	SMT
405 C ---	WHEN SCALE IS SAME FOR ALL USE WIDEST OF ALL THREE SCALES FOUND	SMT
406	IF(SEI .EQ. 0) THEN	SMT
407	DO 41 IK=1,5	SMT
408	VYMIN(IK)=YMIN	SMT
409	VYMAX(IK)=YMAX	SMT
410	41 CONTINUE	SMT
411	ENDIF	SMT
412 C		SMT
413 C		SMT
414 C	PROCESS BOXPLOTS USING VERTICAL SCALE AS DETERMINED	SMT
415 C	ONE CALL FOR EACH ESTIMATOR USED.	SMT
416	50 CONTINUE	SMT
417 C	CLEAR COLOR PLOT ARRAY	
418	CALL CLRCLR(COLRPLT)	SMT
419	GV(1)=VYMIN(1)	SMT
420	GV(2)=VYMAX(1)	SMT
421	WRITE(5,552)	
422 552	FORMAT('/PROCESSING ESTIMATOR # 1')	
423	CALL PRST(GEST1, ISEED1, N, M, NE, L, RG, D, VYMIN(1), VYMAX(1),	SMT
424	* Y, GV, TTL1, NSR, IFIL, NPRT, MSE, VMSE(1,1), IPR, VMX1,	SMT
425	* IBIV, IBPTR, BIV1, INSR, GPV1, GST1, GBA1, GBV1, GBS1, GVV1,	
426	* IBWPRT, NCPRT, NCOLRNDX, COLRXIS, 1, NEST,	SMT
427	* COLRPLT, COLRSTAT, BA, BV, BS, V, DLH, VSCALE, IWIDTH, LABEL)	
428 C		SMT
429	IF (NEST. LT. 2) GO TO 80	SMT
430	WRITE(5,553)	
431 553	FORMAT('/PROCESSING ESTIMATOR #2')	
432	CALL PRST(GEST2, ISEED2, N, M, NE, L, RG, D, VYMIN(2), VYMAX(2),	SMT
433	* Y, GV, TTL2, NSR, IFIL, NPRT, MSE, VMSE(1,2), IPR, VMX2,	SMT
434	* IBIV, IBPTR, BIV2, INSR, GPV2, GST2, GBA2, GBV2, GBS2, GVV2,	SMT
435	* IBWPRT, NCPRT, NCOLRNDX, COLRXIS, 2, NEST,	
436	* COLRPLT, COLRSTAT, BA, BV, BS, V, DLH, VSCALE, IWIDTH, LABEL)	
437 C		SMT
438	IF (NEST. LT. 3) GO TO 80	SMT
439	WRITE(5,554)	
440 554	FORMAT('/PROCESSING ESTIMATOR # 3')	
441	CALL PRST(GEST3, ISEED3, N, M, NE, L, RG, D, VYMIN(3), VYMAX(3),	SMT

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442      * Y,GV,TTL3,NSR,IFIL, NPRT,MSE,VMSE(1,3), IPR,VMX3,      SMT
443      * IBIV,IBPTR,BIV3, INSR,GPV3,GST3,GBA3,GBV3,GBS3,GVV3,      SMT
444      * IBWPRT,NCPRT,NCOLRNDX,COLRXIS,3,NEST,
445      * COLRPLT,COLRSTAT,BA,BV,BS,V,DLH,VSCALE,IWIDTH,LABEL)
446 C
447      IF (NEST. LT. 4) GO TO 80      SMT
448      WRITE(5,556)      SMT
449 556      FORMAT('PROCESSING ESTIMATOR # 4')
450      CALL PRST(GEST4,ISEED4,N,M,NE,L,RG,D,VYMIN(4),VYMAX(4),      SMT
451      * Y,GV,TTL4,NSR,IFIL, NPRT,MSE,VMSE(1,4), IPR,VMX4,      SMT
452      * IBIV,IBPTR,BIV4, INSR,GPV4,GST4,GBA4,GBV4,GBS4,GVV4,      SMT
453      * IBWPRT,NCPRT,NCOLRNDX,COLRXIS,4,NEST,
454      * COLRPLT,COLRSTAT,BA,BV,BS,V,DLH,VSCALE,IWIDTH,LABEL)
455 C
456      IF (NEST. LT. 5) GO TO 80      SMT
457      WRITE(5,557)      SMT
458 557      FORMAT('PROCESSING ESTIMATOR # 5')
459      CALL PRST(GEST5,ISEED5,N,M,NE,L,RG,D,VYMIN(5),VYMAX(5),      SMT
460      * Y,GV,TTL5,NSR,IFIL, NPRT,MSE,VMSE(1,5), IPR,VMX5,      SMT
461      * IBIV,IBPTR,BIV4, INSR,GPV5,GST5,GBA5,GBV5,GBS5,GVV5,      SMT
462      * IBWPRT,NCPRT,NCOLRNDX,COLRXIS,5,NEST,
463      * COLRPLT,COLRSTAT,BA,BV,BS,V,DLH,VSCALE,IWIDTH,LABEL)
464 C
465      80 CONTINUE      SMT
466 C
467 C      IF COLOR FLAG NOT SET, SKIP COLOR OUTPUT SECTION
468 C      IF WE ARE ON SECOND STAGE OF A RESTART RUN, DON'T DO THE COLOR PART.
469      IF(ICOLOR.EQ.0.OR.IRST.EQ.2)GOTO 340
470 C
471 C      OUTPUT SECTION FOR COLOR COMBINED BOXPLOTS
472 C      OUTPUT SECTION FOR COLOR COMBINED BOXPLOTS
473 C      OUTPUT SECTION FOR COLOR COMBINED BOXPLOTS
474 C      OUTPUT SECTION FOR COLOR COMBINED BOXPLOTS
475 C
476 C
477      WRITE(6,325)N,M,D
478 325      FORMAT('1',5X,'SMTB COMBINED ESTIMATOR BOXPLOTS:  SAMPLE SIZE:'
479      * ,I7,' NO. REPLICATIONS: ',I4,' DEG REGRESSION: ',I2/' ',131('-'))
480      DO 303 K=50,1,-1
481      IF(MOD(K,5).NE.0)GO TO 304
482      YLABEL=(K-DLH(2))/VSCALE+YMIN
483      WRITE(6,622)YLABEL
484 622      FORMAT(' ',G8.2,'-')
485      CALL SETCOLR(1)
486      WRITE(6,322)(COLRPLT(I,K,1),I=1,IWIDTH)
487      WRITE(6,322)(COLRPLT(I,K,1),I=1,IWIDTH)
488      CALL SETCOLR(0)
489      WRITE(6,364)
490      CALL SETCOLR(2)
491      WRITE(6,322)(COLRPLT(I,K,2),I=1,IWIDTH)
492      WRITE(6,322)(COLRPLT(I,K,2),I=1,IWIDTH)
493 322      FORMAT('+',9X,122A1)
494      CALL SETCOLR(6)
495      WRITE(6,322)(COLRPLT(I,K,3),I=1,IWIDTH)
496      WRITE(6,322)(COLRPLT(I,K,3),I=1,IWIDTH)
497      CALL SETCOLR(3)

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498      WRITE(6,322)(COLRPLT(I,K,4),I=1,IWIDTH)
499      WRITE(6,322)(COLRPLT(I,K,4),I=1,IWIDTH)
500      CALL SETCOLR(0)
501      WRITE(6,322)(COLRPLT(I,K,5),I=1,IWIDTH)
502      WRITE(6,322)(COLRPLT(I,K,5),I=1,IWIDTH)
503      GOTO 303
504 304  CONTINUE
505      WRITE(6,363)
506 363  FORMAT(9X,'|')
507      CALL SETCOLR(1)
508      WRITE(6,322)(COLRPLT(I,K,1),I=1,IWIDTH)
509      WRITE(6,322)(COLRPLT(I,K,1),I=1,IWIDTH)
510      CALL SETCOLR(0)
511      WRITE(6,364)
512 364  FORMAT('+',131X,'|')
513      CALL SETCOLR(2)
514      WRITE(6,322)(COLRPLT(I,K,2),I=1,IWIDTH)
515      WRITE(6,322)(COLRPLT(I,K,2),I=1,IWIDTH)
516      CALL SETCOLR(6)
517      WRITE(6,322)(COLRPLT(I,K,3),I=1,IWIDTH)
518      WRITE(6,322)(COLRPLT(I,K,3),I=1,IWIDTH)
519      CALL SETCOLR(3)
520      WRITE(6,322)(COLRPLT(I,K,4),I=1,IWIDTH)
521      WRITE(6,322)(COLRPLT(I,K,4),I=1,IWIDTH)
522      CALL SETCOLR(0)
523      WRITE(6,322)(COLRPLT(I,K,5),I=1,IWIDTH)
524      WRITE(6,322)(COLRPLT(I,K,5),I=1,IWIDTH)
525 303  CONTINUE
526      CALL SETCOLR(0)
527      WRITE(6,326)(COLRXIS(I,1),I=1,IWIDTH)
528 326  FORMAT(9X,'+',122A1,'+')
529      WRITE(6,327)(COLRXIS(I,2),I=1,IWIDTH)
530 327  FORMAT(10X,122A1)
531      DO 390 J=1,NEST
532      WRITE(6,370)(NE(NCOLRNDX(I)),I=1,NCPR)
533 370  FORMAT('OSUBSAMPLE SIZE: ',18X,3(I8,6X))
534      WRITE(6,371)J,(COLRSTAT(NCOLRNDX(I),1,J),I=1,NCPR)
535 371  FORMAT(' ESTIMATOR ',I1,' : MEAN: ',8X,3G14.4)
536      WRITE(6,372)(COLRSTAT(NCOLRNDX(I),2,J),I=1,NCPR)
537 372  FORMAT(' ',15X,'STD: ',8X,3G14.4)
538      WRITE(6,373)(COLRSTAT(NCOLRNDX(I),3,J),I=1,NCPR)
539 373  FORMAT(' ',15X,'STD MEAN: ',5X,3G14.4)
540 390  CONTINUE
541      IF(NEST.GE.1)THEN
542      WRITE(6,374)
543 374  FORMAT('OESTIMATOR 1: ')
544      CALL SETCOLR(1)
545      WRITE(6,375)TTL1
546      WRITE(6,375)TTL1
547 375  FORMAT('+',14X,A120)
548      CALL SETCOLR(0)
549      ENDIF
550      IF(NEST.GE.2) THEN
551      WRITE(6,376)
552      CALL SETCOLR(0)
553 376  FORMAT(' ESTIMATOR 2: ')

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554      CALL SETCOLR(2)
555      WRITE(6,375)TTL2
556      WRITE(6,375)TTL2
557      CALL SETCOLR(0)
558  ENDIF
559  IF(NEST.GE. 3) THEN
560      WRITE(6,377)
561 377  FORMAT(' ESTIMATOR 3: ')
562      CALL SETCOLR(6)
563      WRITE(6,375)TTL3
564      WRITE(6,375)TTL3
565      CALL SETCOLR(0)
566  ENDIF
567  IF(NEST.GE. 4) THEN
568      WRITE(6,378)
569 378  FORMAT(' ESTIMATOR 4: ')
570      CALL SETCOLR(3)
571      WRITE(6,375)TTL4
572      WRITE(6,375)TTL4
573      CALL SETCOLR(0)
574  ENDIF
575  IF(NEST.GE. 5) THEN
576      WRITE(6,379)
577 379  FORMAT(' ESTIMATOR 5: ')
578      CALL SETCOLR(0)
579      WRITE(6,375)TTL5
580      WRITE(6,375)TTL5
581  ENDIF
582  C THIS IS THE LAST LINE OF OUTPUT.  IF NO COLOR, PUT IN ON LAST SHEET.
583  C END UP HERE IF DOING RESTART, OR NO COLOR OUTPUT.
584 340  WRITE(6,122) GV
585  C --- SAVE RESTART INFORMATION
586      IF(IRST.GT. 0) THEN
587          REWIND 2
588  C THESE WRITE STATEMENTS ARE BROKEN UP SO THE DEFAULT UNFORMATTED
589  C RECORD LENGTH WILL HOLD THE DATA.  THE USER IS THEN UNCONCERNED WITH
590  C RUNTIME PARAMETERS TO CHANGE THE RECORD LENGTH (R/M FORTRAN)
591  C
592      WRITE(2)N,M,NE,L,D,NSR,NEST,SEI,ISEED1,ISEED2,ISEED3,ISEED4,
593  * ISEED5,VYMIN,VYMAX
594      WRITE(2)((GPV1(I,J,1),I=1,8),J=1,11)
595      WRITE(2)((GPV1(I,J,2),I=1,8),J=1,11)
596      WRITE(2)GST1
597      WRITE(2)GBA1,GBV1,GBS1,GVV1
598      IF(NEST.GE. 2) THEN
599          WRITE(2)((GPV2(I,J,1),I=1,8),J=1,11)
600          WRITE(2)((GPV2(I,J,2),I=1,8),J=1,11)
601          WRITE(2)GST2
602          WRITE(2)GBA2,GBV2,GBS2,GVV2
603      ENDIF
604      IF(NEST.GE. 3) THEN
605          WRITE(2)((GPV3(I,J,1),I=1,8),J=1,11)
606          WRITE(2)((GPV3(I,J,2),I=1,8),J=1,11)
607          WRITE(2)GST3
608          WRITE(2)GBA3,GBV3,GBS3,GVV3
609      ENDIF

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610         IF(NEST .GE. 4) THEN
611             WRITE(2)((GPV4(I,J,1),I=1,8),J=1,11)
612             WRITE(2)((GPV4(I,J,2),I=1,8),J=1,11)
613             WRITE(2)GST4
614             WRITE(2)GBA4,GBV4,GBS4,GVV4
615         ENDIF
616         IF(NEST .GE. 5) THEN
617             WRITE(2)((GPV5(I,J,1),I=1,8),J=1,11)
618             WRITE(2)((GPV5(I,J,2),I=1,8),J=1,11)
619             WRITE(2)GST5
620             WRITE(2)GBA5,GBV5,GBS5,GVV5
621         ENDIF
622         WRITE(6,*) '*** THIS WAS A RESTART RUN. NSR START/END=',INSR,NSR
623     ENDIF
624 C
625 C --- BIVARIATE HISTOGRAMS
626 C
627     IF(IBIV .EQ. 1 .AND. NEST.GT.1) THEN
628         DO 120 K=1,L
629             IBP=IBPTR(K)
630             DO 201 I=1,IBP
631                 TX(I)=BIV1(I,K)
632                 TY(I)=BIV2(I,K)
633 201         CONTINUE
634 C
635         WRITE(6,123) 'BIVARIATE HISTOGRAM FOR ESTIMATORS 1 & 2.',
636             *           'SECTION SIZE=',NE(K)
637         CALL BIHSPC(TX,TY, IBP,Y)
638         WRITE(6,*) '1 - ', TTL1
639         WRITE(6,*) '2 - ', TTL2
640 C
641         IF(NEST .LT. 3) GO TO 120
642         DO 202 I=1,IBP
643             TX(I)=BIV1(I,K)
644             TY(I)=BIV3(I,K)
645 202         CONTINUE
646         WRITE(6,123) 'BIVARIATE HISTOGRAM FOR ESTIMATORS 1 & 3.',
647             *           'SECTION SIZE=',NE(K)
648         CALL BIHSPC(TX,TY, IBP,Y)
649         WRITE(6,*) '1 - ', TTL1
650         WRITE(6,*) '3 - ', TTL3
651 C
652         DO 203 I=1,IBP
653             TX(I)=BIV2(I,K)
654             TY(I)=BIV3(I,K)
655 203         CONTINUE
656         WRITE(6,123) 'BIVARIATE HISTOGRAM FOR ESTIMATORS 2 & 3.',
657             *           'SECTION SIZE=',NE(K)
658         CALL BIHSPC(TX,TY, IBP,Y)
659         WRITE(6,*) '2 - ', TTL2
660         WRITE(6,*) '3 - ', TTL3
661 120     CONTINUE
662     ENDIF
663 C JUMP TO HERE IF AN ERROR EXISTS IN THE INPUT DATA. RETURN .
664 8001 CONTINUE
665 C

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666 123 FORMAT('1',A45,A13,I5) SMT
667 122 FORMAT(/' *** WIDEST Y VALUES FOUND: YMIN=',G10.4, SMT
668 * - YMAX=',G10.4,' *** SMTB ***') SMT
669 103 FORMAT(' *** ERROR...L MUST BE AN INTEGER BETWEEN 2 AND 8. ***') SMT
670 104 FORMAT(' *** ERROR...M MUST BE AN INTEGER BETWEEN 1 AND 100. ***') SMT
671 106 FORMAT(' *** ERROR...NEST MUST BE 3 OR LESS. ***') SMT
672 107 FORMAT(' *** ERROR...N/NE(L) MUST BE 1 OR GREATER TO COMPUTE', SMT
673 +' STATISTICS.',/, ' INCREASE N OR DECREASE NE(L). ***') SMT
674 108 FORMAT(' *** ERROR...D MUST BE LESS THAN OR EQUAL TO 3. ***') SMT
675 110 FORMAT(' *** WARNING... NE ARRAY ELLEMENTS ARE NOT IN ORDER OF '/' SMT
676 +' INCREASING SIZE. IF NE(1) IS NOT SMALLEST ELEMENT, SCALING' SMT
677 +' MAY CAUSE POINTS TO FALL OUTSIDE RANGE OF SCALE.') SMT
678 111 FORMAT(' *** ERROR...NSR MUST NOT BE LESS THAN 1 ***') SMT
679 END SMT
680 C SMT
681 SUBROUTINE PRST(GENEST,ISEED,N,M,NE,L,RG,UD,YMIN,YMAX,Y, SMT
682 * GV,TTL,NSR,IFIL,NPRT,MSE,VMSE,IPR,VMX,IBIV,IBPTR,BIV, SMT
683 * INSR,GPVAL,GSTAT,GBA,GBV,GBS,GVV,IBWPRT,NCPRT,NCOLRNDX, SMT
684 * COLRXIS,IEST,NEST, SMT
685 * COLRPLT,COLRSTAT,BA,BV,BS,V,DLH,VSCALE,IWIDTH,LABEL) SMT
686 PARAMETER (NBROWS=500) SMT
687 C SMT
688 C REGRESSION ADJUSTED ESTIMATE SMT
689 C CALCULATES ESTIMATES FROM USER DATA USING "EST" FUNCTION SMT
690 C PLOTS BASIC OR RETRENCHED GRAPH ON LINE PRINTER SMT
691 C * GENEST = SUBROUTINE GENERATE THE DATA AND PRODUCE ESTIMATE SMT
692 C * ISEED = SEED FOR GENEST SMT
693 C N = NUMBER OF VALUES IN EACH REPLICATION (M*N MUST BE <= 50000) SMT
694 C M = NO. OF REPLICATIONS (MUST BE <= 100) SMT
695 C Y = USERS VECTOR WITH M CONSECUTIVE BATCHES OF N VALUES EACH SMT
696 C L = NO. OF SECTION SIZES (MUST BE BETWEEN 1 AND 8) SMT
697 C NE = ARRAY WITH THE L SUBSAMPLE SIZES (MUST BE IN ASCENDING ORDER) SMT
698 C UD = DEGREE OF THE REGRESSION (MUST BE <= 6 & <= L-1 ) SMT
699 C GV=WIDEST Y VALUES. PRINTED ON LAST PLOT TO AID IN SETTING SCALE SMT
700 C NSR=NUMBER OF REPETITIONS OF THE PLOT (EXTRA SUMMARY PLOT WHEN >1) SMT
701 C INSR=START SUPER-REPLICATION. NORMALLY 1 EXCEPT ON RESTART SMT
702 C IEST=NUMBER OF ESTIMATOR WE ARE CURRENTLY DEALING WITH (1,2,OR3) SMT
703 C IBWPRT=0-NO STD PRINTOUTS - 1 STD PRINTOUTS SMT
704 C NCPRT=#OF SAMPLE SIZES FOR WHICH TO PRINT COLOR BOXPLOTS SMT
705 C NCOLRNDX=ARRAY INDX TO NE() FOR COLOR BOXPLOTS SMT
706 C COLRPLT=CHARACTER 3D ARRAY, 1 SHEET FOR EACH COLOR/ESTIMATOR SMT
707 C ICLRLOCK=2D ARRAY, LOCS OF BOXPLOTS IN EACH SHEET SMT
708 C COLRXIS=2DARRAY, CHAR. COLOR X AXIS SMT
709 C SMT
710 C SMT
711 real*8 ISEED SMT
712 INTEGER IBIV,IBPTR(8),NCOLRNDX(3),ICLRLOCK(5,3) SMT
713 CHARACTER*120 TTL SMT
714 CHARACTER*1 PLOT(122,50), CBAR,BLK,DASH,DOT,SYM(11),XAXIS(122,2), SMT
715 * COLRPLT(122,50,5),COLRXIS(122,2),TEMPLOT(122,50) SMT
716 CHARACTER*8 LABEL(7) SMT
717 DIMENSION NE(8) SMT
718 INTEGER NB(8),LOCX(8),D1,IWIDTH,UD,D,LT,DT,RG, DA,D1A SMT
719 REAL BIV(NBROWS,8) SMT
720 REAL*4 PVAL(8,11), QVAL(11),VNORM(11), VMSE(8) SMT
721 REAL*4 DLH(4),Y(1),GV(2), SVAR(8),COLRSTAT(8,7,5) SMT

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722	REAL*4 RH(8,100),STAT(8,7),VT(8), VMX(8,4),VXCNT(8,4)	SMT
723	REAL*8 SUM2,SUM3,SUM4	SMT
724	REAL*4 RA(8,7),RV(8,7),B(7,100),V(7),BA(7),BV(7),BS(7),RT(8),BT(8)	SMT
725	INTEGER ISCOL(5)	SMT
726	REAL*8 GSTAT(8,7,2), GPVAL(8,11,2)	SMT
727	REAL*8 XSTAT(8,7,2), XPVAL(8,11,2)	SMT
728	REAL*8 GBA(7,2), GBV(7,2), GBS(7,2), GVV(7,2)	SMT
729	REAL*8 XBA(7,2), XBV(7,2), XBS(7,2), XVV(7,2)	SMT
730	DATA B/700*0./	SMT
731	DATA BLK/' ', DASH/'-'/, CBAR/' '/, DOT/'.'/	SMT
732	DATA ISCOL/1,2,4,5,7/	SMT
733	DATA SYM/'&','\$','+','%','Q','M','Q','%','+', '\$','&'/, NSYM/11/	SMT
734	DATA QVAL/.01,.025,.05,.10,.25,.5,.75,.90,.95,.975,.99/	SMT
735	DATA VNORM/-2.33,-1.96,-1.645,-1.29,-.67,0.,	SMT
736	* .67,1.29,1.645,1.96,2.33/	SMT
737	DATA ICSPCE/1/	
738	JCSPCE=(ICSPCE+3)*NEST	
739	DO 401 I=1,7	
740	401 V(I)=0	
741	DLH(1)=1.	
742	DLH(2)=1.	
743	DLH(3)=122.	
744	DLH(4)=50.	
745	LABEL(1)='MEAN'	
746	LABEL(2)='STD'	
747	LABEL(3)='STD MEAN'	
748	LABEL(4)='SKEWNESS'	
749	LABEL(5)='KURTOSIS'	
750	LABEL(6)='M. S. E '	
751	LABEL(7)='SER. COR. '	
752	C --- CLEAR COUNTS MATRIX FOR PERCENTILE PLOT	SMT
753	DO 1 I=1,8	SMT
754	DO 2 J=1,4	SMT
755	VXCNT(I,J)=0.	SMT
756	2 CONTINUE	SMT
757	1 CONTINUE	SMT
758	D=MINO(UD,L-1)	SMT
759	C --- DEGREE OF REGRESSION FOR AVERAGES LIMITED TO 4	SMT
760	DA=MIN(4, D)	SMT
761	D1=D+1	SMT
762	D1A=DA+1	SMT
763	IX1=8	SMT
764	IX2=7	SMT
765	MN=M*N	SMT
766	IWIDTH= IFIX(DLH(3))	SMT
767	C BUILD REGRESSION MATRICES FOR AVERAGES AND VARIANCES	SMT
768	DO 84 K=1,L	SMT
769	DO 86 J=1,D1	SMT
770	T=FLOAT(NE(L))/FLOAT(NE(K))	SMT
771	RA(K,J)=T*(J-1)	SMT
772	RV(K,J)=T*(FLOAT(J)*.5)	SMT
773	86 CONTINUE	SMT
774	84 CONTINUE	SMT
775	C SET HORIZONTAL XMIN, XMAX	SMT
776	XMIN=.7*NE(1)	SMT
777	XMAX=1.2*NE(L)	SMT

```

778 C --- SCALING FACTORS FOR REGR., QUANTILE PLOT & NORM. QUANTILE (QVSC) SMT
779 VSCALE=(DLH(4)-DLH(2))/(YMAX-YMIN) SMT
780 HSCALE=(DLH(3)-DLH(1))/(XMAX-XMIN) SMT
781 QVSC =(DLH(4)-DLH(2))/(3. - (-3.)) SMT
782
783
784 WRITE(5,*)'COMPUTING BOXPLOT LOCATIONS'
785
786
787 C COMPUTE LOCATION OF BOXPLOTS ALONG X-AXIS SMT
788 LAST=-1 SMT
789 DO 5 K=1,L SMT
790 NB(K)=N/NE(K) SMT
791 LOCX(K)=(NE(K)-XMIN)*HSCALE + DLH(1)+.5 SMT
792 IF(LOCX(K).LT. LAST+4) LOCX(K)=LAST+4 SMT
793 LAST=LOCX(K) SMT
794 5 CONTINUE SMT
795 IF(LOCX(L).GT. 120) LOCX(L)=120 SMT
796 C COMPUTE LOCATION OF COLOR BOXPLOTS
797 C WE WILL DO THIS ONCE ONLY. CAN DO ALL ESTIMATOR LOCATIONS FOR COLOR
798 C USING THE FIRST ESTIMATOR POSITIONS AND OFFSETS.
799 IF(IEST.NE.1) GOTO 7
800
801 C ICSPCE IS SPACING FOR COLOR BOXPLOTS (1 ==> 1 SPACE BETWEEN,
802 C 0 ==> ADJACENT)
803
804 C FIRST COMPUTE POSITIONS OF SECOND ESTIMATOR (CENTER)
805
806 DO 6 K=1,NCPRT
807 C
808 C USE SAME HORIZONTAL SCALE AS DETERMINED ABOVE FOR BW BOXPLOTS
809 C WE ARE COMPUTING THE LOCATIONS OF THE SECOND PLOT OF EACH
810 C GROUP, AND WE WILL THEN OFFSET THE OTHERS BASED ON THE SPACING
811 C COMPUTE TENTATIVE POSITION BASED ON SCALE, THEN CHECK BOUNDS
812 KK=(NE(NCOLRNDX(K))-XMIN)*HSCALE+DLH(1)+.5
813
814 C MINIMUM BOXPLOT POSITION IS 6+ICSPCE, FOR CENTER(SECOND) BOXPLOT
815 IF(K.EQ.1)THEN
816 IF(KK.GE. 6+ICSPCE)ICLRLOCX(2,1)=KK
817 IF(KK.LT. 6+ICSPCE)ICLRLOCX(2,1)=6+ICSPCE
818 ENDIF
819 C CHECK THAT THERE IS AT LEAST (3+ICSPCE)*NEST NUMBER OF SPACES
820 C BETWEEN EACH GROUP OF PLOTS
821 C SO THAT ALL THE ESTIMATORS WILL FIT. THIS IS JCSPCE.
822
823 IF(K.EQ.2) THEN
824 IF(KK-ICLRLOCX(2,1).LT. JCSPCE)
825 * ICLRLOCX(2,2)=ICLRLOCX(2,1)+JCSPCE
826 IF(KK-ICLRLOCX(2,1).GE. JCSPCE)ICLRLOCX(2,2)=KK
827 ENDIF
828
829 IF(K.EQ.3) THEN
830 IF(KK-ICLRLOCX(2,2).LT. JCSPCE)
831 * ICLRLOCX(2,3)=ICLRLOCX(2,2)+JCSPCE
832 IF(KK-ICLRLOCX(2,2).GE. JCSPCE)ICLRLOCX(2,3)=KK
833 ENDIF

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834 C NOW OFFSET THE OTHER ESTIMATOR'S LOCATIONS TO EITHER SIDE OF THESE
835
836 IF(NEST.GE.2)ICLRLOCX(1,K)=ICLRLOCX(2,K)-3-ICSPCE
837 IF(NEST.GE.3)ICLRLOCX(3,K)=ICLRLOCX(2,K)+3+ICSPCE
838 IF(NEST.GE.4)ICLRLOCX(4,K)=ICLRLOCX(2,K)+6+ICSPCE+ICSPCE
839 IF(NEST.GE.5)ICLRLOCX(5,K)=ICLRLOCX(2,K)+9+3*ICSPCE
840 C
841 C IF THE POSITION OF THE RIGHTMOST MEMBER OF THE GROUP OF BOXPLOTS
842 C EXCEEDS THE RIGHT MARGIN, MOVE THEM ALL BACK AN AMOUNT OF THE
843 C THE DISTANCE FROM THE MARGIN, THEN SET THE LAST ONE AT THE MARGIN
844 C
845 IF(ICLRLOCX(NEST,K).GT.120) THEN
846 DO 8 I=1,NEST-1
847 8 ICLRLOCX(I,K)=ICLRLOCX(I,K)-(ICLRLOCX(5,K)-120)
848 ICLRLOCX(NEST,K)=120
849 ENDIF
850 6 CONTINUE
851 7 CONTINUE
852 C
853 C---- LABEL X-AXIS
854 DO 115 I=1,122
855 XAXIS(I,1)=DASH
856 XAXIS(I,2)=BLK
857 IF(IEST.EQ.1)COLRXIS(I,1)=DASH
858 IF(IEST.EQ.1)COLRXIS(I,2)=BLK
859 115 CONTINUE
860 DO 130 J=1,L
861 IBPTR(J)=0
862 XAXIS(LOCX(J),1)=CBAR
863 IK = NE(J)
864 IX = LOCX(J)
865 CALL NUMPRT(IX,2,IK,XAXIS)
866 130 CONTINUE
867 C
868 C THE X AXIS POSITION MARKER IS PLACED AT THE POSITION OF THE SECOND
869 C BOXPLOT FOR COLOR COMBINED PLOTS
870 C
871 IF(IEST.NE.2)GOTO 132
872 DO 131 J=1,NCNPT
873 COLRXIS(ICLRLOCX(IEST,J),1)=CBAR
874 IK=NE(NCOLRNDX(J))
875 IX=ICLRLOCX(IEST,J)
876 CALL NUMPRT(IX,2,IK,COLRXIS)
877 131 CONTINUE
878 C FIND NO. OF STATISTICS TO BE CALCULATED AT EACH SAMPLE SIZE
879 132 L1=0
880 L2=0
881 L3=0
882 DO 21 I=1,L
883 K1 = M*(N/NE(I))
884 IF (K1.GE.2) L1=I
885 IF (K1.GE.3) L2=I
886 IF (K1.GE.4) L3=I
887 21 CONTINUE
888 DT=MIN(D1, L1)
889 C --- CLEAR GRANDTOTALS FOR SUMMARY PAGE EXCEPT WHEN RESTARTING

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890      IF(INSR .EQ. 1) CALL CLRGT(GBA,GBV,GBS,GVV,GSTAT,GPVAL)      SMT
891 C
892 C --- OUTER LOOP ADDED 07-16-84 TO DO MULTIPLE RUNS PER NSR PARAMETER SMT
893 C
894      DO 2000 ISREP=INSR,NSR SMT
895      WRITE(5,*) 'ESTIMATOR ',IEST,' SUPER-REP #',ISREP,' (OF ',NSR,')' SMT
896 C      CLEAR PLOT ARRAY, BW ONLY SMT
897      CALL CLRPA(PLOT) SMT
898 C
899 C INITIALIZE COUNTER FOR COLOR PLOT INDEX
900 C
901      KCOUNT=1
902      DO 80 K=1,L SMT
903      WRITE(5,557)NE(K)
904 557  FORMAT('/SUBSAMPLE SIZE: ',I5)
905      NBK=NB(K) SMT
906 C      SECTION & COMPUTE ESTIMATORS FOR SIZE K SMT
907      CALL SECEST(GENEST,ISEED,N,M,NE(K),Y,KP) SMT
908 C      AVERAGE ESTIMATES OF SIZE NE(K) FOR EACH OF M REPLICATIONS SMT
909      KP=0 SMT
910      DO 10 I=1,M SMT
911      RH(K,I)=0. SMT
912      DO 15 J=1,NBK SMT
913      KP=KP+1 SMT
914      GV(1)=AMIN1(GV(1), Y(KP)) SMT
915      GV(2)=AMAX1(GV(2), Y(KP)) SMT
916      RH(K,I)=RH(K,I)+Y(KP) SMT
917 15  CONTINUE SMT
918      RH(K,I)=RH(K,I)/FLOAT(NBK) SMT
919 10  CONTINUE SMT
920 C      COMPUTE MEAN AND MOMENT ESTIMATES SMT
921      CALL CMPMOM(Y,KP,VMSE,MSE,K, STAT,SVAR) SMT
922      DO 180 IM1=1,KP SMT
923 C --- APPEND TO BIVARIATE MATRICES SMT
924      IF(IBPTR(K) .LT. NBROWS) THEN SMT
925      IBPTR(K)=IBPTR(K)+1 SMT
926      BIV(IBPTR(K), K)=Y(IM1) SMT
927      ENDIF SMT
928 C --- FREQUENCY COUNTS FOR PERCENTILE PLOTS SMT
929      IF(IPR .EQ. 1) THEN SMT
930      DO 181 IK=1,4 SMT
931      IF(Y(IM1) .LE. VMX(K,IK)) VXCNT(K,IK)=VXCNT(K,IK) + 1 SMT
932 181  CONTINUE SMT
933      ENDIF SMT
934 180  CONTINUE SMT
935      CALL BOXPRT(Y,KP,LOCX(K),PLOT,RG,XMIN,YMIN,XMAX,YMAX,VSCALE) SMT
936 C FOR COLOR BOXPLOTS, IF K, THE INDEX THROUGH ALL THE SAMPLE SIZES,
937 C IS EQUAL TO THE INDEX OF SAMPLE SIZES SPECIFIED FOR COLOR PLOTS,
938 C THEN PREPARE A BOXPLOT FOR THIS SAMPLE SIZE, AT LOCATION DETERMINED
939 C ABOVE. MOVE SHEET OF 3D PLOT ARRAY TO TEMP (2D ARRAY), CALL BOXPRT, AND
940 C THEN RESTORE SHEET OF 3D ARRAY.
941 C
942 C IF KCOUNT GT NCPRT THEN WE HAVE DONE ALL THE SAMPLE SIZES FOR THIS
943 C ESTIMATOR
944 C
945      IF(KCOUNT.GT.NCPRT)GOTO 184

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946      IF(K. NE. NCOLRNDX(KCOUNT))GOTO 184
947 C
948 C FOUND A SAMPLE SIZE, AND NOW WANT A COLOR BOXPLOT
949 C FIRST CLEAR TEMPLOT ARRAY, AND THEN PUT BOX PLOT IN IT
950      CALL CLRPA(TEMPLOT)
951 C
952 C FOR SUPERREPS, ONLY DO COLOR COMBINATION FOR FIRST SUPERREP
953      IF(ISREP. GT. 1)GOTO 182
954      CALL BOXPRT(Y,KP,ICLRLOCX( IEST,KCOUNT),TEMPLOT, RG,XMIN,YMIN,XMAX,
955      * YMAX,VSCALE)
956      DO 183 KK=1,122
957      DO 183 IKK=1,50
958 183      IF(COLRPLT(KK,IKK, IEST). EQ. BLK)COLRPLT(KK,IKK, IEST)=TEMPLOT(KK,IKK
959      C,
960 182      CONTINUE
961 C
962 C
963      KCOUNT=KCOUNT+1
964 C
965 C --- STORE QUANTILES FOR 2ND PAGE PLOT
966 184      DO 18 IQ=1,NSYM
967          PVAL(K,IQ)=PCTL(Y,KP,QVAL(IQ),1)
968      18      CONTINUE
969      80      CONTINUE
970 C
971 C IF D1. LT. 2 THEN NO REGRESSIONS OR PLOTING CAN BE DONE
972 C
973      IF(D1. LT. 2) GO TO 113
974      DO 92 K=1,M
975          DO 47 J=1,L
976              RT(J)=RH(J,K)
977      47      CONTINUE
978      CALL RREG(RA,RT,BT,L,D1A,IX1,IX2)
979      B(1,K)=BT(1)
980      DO 23 KT=2,D1A
981          B(KT,K)=BT(KT)*NE(L)**(KT-1)
982      23      CONTINUE
983      92      CONTINUE
984 C
985 C AVERAGE REGRESSION COEFF. OVER M REPLICATIONS & CALC. VARIANCE
986      CALL COEFF(B,M,D1A, BA,BV,BS,V)
987 C
988 C ESTABLISH REGRESSION LINE & ASYMPTOTE
989 C
990      DO 98 I=3,IWIDTH
991 C      MAP I FROM DEVICE SPACE TO USER SPACE
992      UX=(I-DLH(1))/HSCALE + XMIN
993 C      COMPUTE THE Y VALUE FROM X AND THE REGRESSION COEFFICIENTS.
994      UY=BA(1)
995      DO 99 J=1,DA
996          UY=UY+BA(J+1)/UX**J
997      99      CONTINUE
998 C
999 C      MAP THE Y VALUE FROM USER SPACE TO DEVICE SPACE
1000      J=(UY-YMIN)*VSCALE + DLH(2) + .5
1001      IF(J .LT. 1 .OR. J .GT. 50) GO TO 98

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```

1002          IF(PLOT(I,J) .EQ. BLK) PLOT(I,J)=DOT                                SMT
1003 C COMMENTED OUT THE LINES TO PUT REGRESSION LINES IN COLOR PLOT
1004 C          IF(ISREP.EQ.1.AND.COLRPLT(I,J,IEST).EQ.BLK)
1005 C      C          COLRPLT(I,J,IEST)=DOT
1006
1007          98 CONTINUE                                                            SMT
1008 C                                                                 SMT
1009 C          SCALE ASYMPOTTE, BETA0, AND PLOT ACROSS PLOT.                      SMT
1010          J=(BA(1)-YMIN)*VSCALE + DLH(2) + .5                                SMT
1011          IF(J .LT. 1 .OR. J .GT. 50) GO TO 117                               SMT
1012          DO 120 I=3,IWIDTH                                                    SMT
1013          IF(PLOT(I,J) .EQ. BLK) PLOT(I,J)=DASH                               SMT
1014          IF(ISREP.EQ.1.AND.COLRPLT(I,J,IEST).EQ.BLK)
1015      C          COLRPLT(I,J,IEST)=DASH
1016          120 CONTINUE                                                            SMT
1017 C                                                                 SMT
1018 C          REGRESSION ON VARIANCES FROM EACH SEGMENT WITH A VARIANCE.          SMT
1019 C                                                                 SMT
1020          117 CONTINUE                                                            SMT
1021          IF(DT.LT.2) GO TO 113                                                  SMT
1022          DO 48 J=1,L                                                            SMT
1023 C --- MODIFIED FOR MEAN SQUARE ERROR      08-22-86                          SMT
1024          VT(J)=SVAR(J)*(NE(J)**0.5)                                           SMT
1025          48 CONTINUE                                                            SMT
1026          CALL RREG(RV,VT,V,L1,DT,IX1,IX2)                                     SMT
1027          DO 77 I=1,DT                                                            SMT
1028          V(I) = V(I)*NE(L)**(FLOAT(I)/2.)                                       SMT
1029          77 CONTINUE                                                            SMT
1030 C --- ACCUMULATE FOR SUMMARY STATISTICS OVER SUPER-REPLICATIONS            SMT
1031          113 CONTINUE                                                            SMT
1032          CALL CMPSUM(BA,BV,BS,V,DT,D1,L,STAT,PVAL,NSYM,                        SMT
1033      *          GBA,GBV,GBS,GVV,GSTAT,GPVAL)                                   SMT
1034 C
1035 C UPDATE COLOR STATISTIC MATRIX WITH STATS FROM THIS ESTIMATOR
1036 C
1037          IF(ISREP.EQ.1) THEN
1038              DO 450 I=1,8
1039              DO 450 J=1,7
1040          450          COLRSTAT(I,J,IEST)=STAT(I,J)
1041          ENDIF
1042 C
1043 C --- SAVE STATISTICS FOR THIS SUPER REPLICATION                            SMT
1044 C - USE FORMATTED FILE FOR EASE IN FURTHER PROCESSING. LABEL THE DATA
1045 C - IN THE FILE
1046 C
1047          IF(IFIL.EQ.1) THEN
1048              WRITE(1,458)TTL
1049          458          FORMAT(A120)
1050              WRITE(1,456)ISREP
1051          456          FORMAT('SUPER-REP #: ',I10)
1052              WRITE(1,452)
1053          452          FORMAT('SAMP SIZE MEAN      STD      SKEWNESS KURTOSIS SER CORR
1054      *')
1055              DO 453 I=1,L
1056          453          WRITE(1,451)NE(I),(STAT(I,ISCOL(J)),J=1,5)                SMT
1057              WRITE(1,454)

```

1058	454	FORMAT(/'QUANT. ROWS: 1 EA FOR .01 .025 .05 .1 .25 .5 .75 .9 .95	
1059		*.975 .99')	
1060		DO 457 J=1,11	
1061	457	WRITE(1,455)(PVAL(I,J),I=1,8)	
1062	455	FORMAT(8G10.4)	
1063	451	FORMAT(I10,(5G10.4))	
1064		ENDIF	
1065	C		SMT
1066	C ---	PRINT ONLY FIRST 3 PLOTS WHEN NPRT=0. ONLY 1 PLOT OTHERWISE	SMT
1067		IF(NPRT.NE.1 .AND. ISREP .GT. 3) GO TO 2000	SMT
1068		IF(NPRT.EQ.1 .AND. ISREP .GT. 1) GO TO 2000	SMT
1069	C IF	BWPRT FLAG IS NOT SET, DONT PRINT THESE STANDARD PRINTOUTS	
1070		IF(IBWPRT.EQ.0)GOTO 2000	
1071	C		
1072	C		SMT
1073	C	PLOT *****	SMT
1074	C		SMT
1075		WRITE(6,102)	SMT
1076		WRITE(6,161) N,M,D	SMT
1077		WRITE(6,101)	SMT
1078		DO 90 K=50,1,-1	SMT
1079		IF(MOD(K,5).NE.0) GO TO 85	SMT
1080		YLABEL=(K-DLH(2))/VSCALE + YMIN	SMT
1081		WRITE(6,103) YLABEL,(PLOT(I,K),I=1,IWIDTH)	SMT
1082		GO TO 90	SMT
1083	85	CONTINUE	SMT
1084		WRITE(6,100) (PLOT(I,K),I=1,IWIDTH)	SMT
1085	90	CONTINUE	SMT
1086		WRITE(6,106) (XAXIS(I,1),I=1,IWIDTH)	SMT
1087		WRITE(6,104) (XAXIS(I,2),I=1,IWIDTH)	SMT
1088		WRITE(6,156)	SMT
1089		WRITE(6,146) (NE(I),I=1,L)	SMT
1090		WRITE(6,157) LABEL(1), (STAT(K,1),K=1,L)	SMT
1091	11	WRITE(6,157) LABEL(2), (STAT(K,2),K=1,L1)	SMT
1092		WRITE(6,157) LABEL(3), (STAT(K,3),K=1,L1)	SMT
1093		IF(MSE .EQ. 1) WRITE(6,157) LABEL(6), (STAT(K,6),K=1,L1)	SMT
1094	12	WRITE(6,158) LABEL(4), (STAT(K,4),K=1,L2)	SMT
1095	13	WRITE(6,158) LABEL(5), (STAT(K,5),K=1,L3)	SMT
1096		IF(D1.LT.2) GO TO 444	SMT
1097		WRITE(6,151) (BA(I),I=1,D1A)	SMT
1098	14	IF(M.LT.2)GO TO 444	SMT
1099		WRITE(6,152) (BV(I),I=1,D1A)	SMT
1100		WRITE(6,153) (BS(I),I=1,D1A)	SMT
1101	444	IF(DT.LE.1) GO TO 999	SMT
1102		WRITE(6,159) (V(I),I=1,DT)	SMT
1103	999	WRITE(6,162)	SMT
1104		WRITE(6,108) TTL	SMT
1105		WRITE(6,201) YMIN,YMAX	SMT
1106	C ---	PREPARE 2ND PAGE PLOT	SMT
1107	C ---	CLEAR PLOT ARRAY	SMT
1108		CALL CLRPA(PLOT)	SMT
1109	C ---	ENTER QUANTILES	SMT
1110		DO 220 K=1,L	SMT
1111		DO 240 IS=1,NSYM	SMT
1112		IQ=(PVAL(K,IS)-YMIN)*VSCALE + 1	SMT
1113		IF(IQ .GE. 1 .AND. IQ .LE. 50) PLOT(LOCX(K), IQ)=SYM(IS)	SMT

1114	240	CONTINUE	SMT
1115	220	CONTINUE	SMT
1116	C ---	PRINT 2ND PAGE	SMT
1117		WRITE(6,202)	SMT
1118		WRITE(6,161) N,M,D	SMT
1119		WRITE(6,101)	SMT
1120		DO 191 J=1,50	SMT
1121		K=51-J	SMT
1122		IF(MOD(K,5).NE.0) GO TO 185	SMT
1123		YLABEL=(K-DLH(2))/VSCALE + YMIN	SMT
1124		WRITE(6,103) YLABEL,(PLOT(I,K),I=1,IWIDTH)	SMT
1125		GO TO 191	SMT
1126	185	CONTINUE	SMT
1127		WRITE(6,100) (PLOT(I,K),I=1,IWIDTH)	SMT
1128	191	CONTINUE	SMT
1129		WRITE(6,106) (XAXIS(I,1),I=1,IWIDTH)	SMT
1130		WRITE(6,104) (XAXIS(I,2),I=1,IWIDTH)	SMT
1131	C ---	PRINT QUANTILE AMOUNTS	SMT
1132		WRITE(6,156)	SMT
1133		WRITE(6,147) (NE(I),I=1,L)	SMT
1134		DO 199 I=1,NSYM	SMT
1135		WRITE(6,167) QVAL(I), (PVAL(K,I),K=1,L)	SMT
1136	199	CONTINUE	SMT
1137		WRITE(6,158) LABEL(7), (STAT(K,7),K=1,L1)	SMT
1138		WRITE(6,108) TTL	SMT
1139	C ---	WHEN NPRT=1 SUPPRESS NORMALIZED PLOTS	SMT
1140		IF(NPRT.EQ. 1) GO TO 2000	SMT
1141	C ---		SMT
1142	C ---	PREPARE 3ND PAGE PLOT	SMT
1143	C ---	CLEAR PLOT ARRAY	SMT
1144		CALL CLRPA(PLOT)	SMT
1145	C ---	NORMALIZE QUANTILES	SMT
1146		DO 1220 K=1,L	SMT
1147		DO 1240 IS=1,NSYM	SMT
1148		IF(STAT(K,2).GT.0) PVAL(K,IS)=(PVAL(K,IS)-STAT(K,1))/STAT(K,2)	SMT
1149		IQ=(PVAL(K,IS)+3.)*QVSC + 1	SMT
1150		IF(IQ.GE. 1.AND. IQ.LE. 50) PLOT(LOCX(K), IQ)=SYM(IS)	SMT
1151	1240	CONTINUE	SMT
1152	1220	CONTINUE	SMT
1153	C ---	ADD RIGHT SIDE NORMAL POINT MARKS	SMT
1154		DO 1260 IS=1,NSYM	SMT
1155		IQ=(VNORM(IS)+3.)*QVSC + 1	SMT
1156		IF(IQ.GE. 1.AND. IQ.LE. 50) PLOT(122, IQ)=SYM(IS)	SMT
1157	1260	CONTINUE	SMT
1158	C ---	PRINT 3RD PAGE	SMT
1159		WRITE(6,203)	SMT
1160		WRITE(6,161) N,M,D	SMT
1161		WRITE(6,101)	SMT
1162		DO 1191 J=1,50	SMT
1163		K=51-J	SMT
1164		IF(MOD(K,5).NE.0) GO TO 1185	SMT
1165		YLABEL=(K-DLH(2))/QVSC - 3.	SMT
1166		WRITE(6,103) YLABEL,(PLOT(I,K),I=1,IWIDTH)	SMT
1167		GO TO 1191	SMT
1168	1185	CONTINUE	SMT
1169		WRITE(6,100) (PLOT(I,K),I=1,IWIDTH)	SMT

1170	1191	CONTINUE	SMT
1171		WRITE(6,106) (XAXIS(I,1),I=1,IWIDTH)	SMT
1172		WRITE(6,104) (XAXIS(I,2),I=1,IWIDTH)	SMT
1173	C ---	PRINT NORMALIZED QUANTILE AMOUNTS	SMT
1174		WRITE(6,156)	SMT
1175		WRITE(6,147) (NE(I),I=1,L)	SMT
1176		DO 1199 I=1,NSYM	SMT
1177		WRITE(6,167) QVAL(I), (PVAL(K,I),K=1,L)	SMT
1178	1199	CONTINUE	SMT
1179		WRITE(6,108) TTL	SMT
1180	C	*****	SMT
1181	2000	CONTINUE	SMT
1182		IF(NSR .EQ. 1) RETURN	SMT
1183		DO 360 I=1,L	SMT
1184		DO 370 J=1,7	SMT
1185		XSTAT(I,J,1)=GSTAT(I,J,1)/NSR	SMT
1186		XSTAT(I,J,2)=(GSTAT(I,J,2)-NSR*XSTAT(I,J,1)**2)/	SMT
1187	*	((NSR-1)*NSR)	SMT
1188		IF(XSTAT(I,J,2) .LT. 0) XSTAT(I,J,2)=0	SMT
1189		XSTAT(I,J,2)=SQRT(XSTAT(I,J,2))	SMT
1190	370	CONTINUE	SMT
1191	360	CONTINUE	SMT
1192		DO 375 K=1,L	SMT
1193		DO 378 IS=1,NSYM	SMT
1194		XPVAL(K,IS,1)=GPVAL(K,IS,1)/NSR	SMT
1195		XPVAL(K,IS,2)=(GPVAL(K,IS,2)-NSR*XPVAL(K,IS,1)**2)/	SMT
1196	*	((NSR-1)*NSR)	SMT
1197		IF(XPVAL(K,IS,2) .GT. 0.) XPVAL(K,IS,2)=SQRT(XPVAL(K,IS,2))	SMT
1198		IF(XPVAL(K,IS,2) .LT. 0.) XPVAL(K,IS,2)=0.	SMT
1199	378	CONTINUE	SMT
1200	375	CONTINUE	SMT
1201	C ---	\$	SMT
1202	C ---	PREPARE SUPER REPLICATIONS QUANTILE PLOT	SMT
1203	C ---	CLEAR PLOT ARRAY	SMT
1204		CALL CLRPA(PLOT)	SMT
1205	C ---	ENTER QUANTILES	SMT
1206		DO 2220 K=1,L	SMT
1207		DO 2240 IS=1,NSYM	SMT
1208		IQ=(XPVAL(K,IS,1)-YMIN)*VSCALE + 1	SMT
1209		IF(IQ .GE. 1 .AND. IQ .LE. 50) PLOT(LOCX(K), IQ)=SYM(IS)	SMT
1210	2240	CONTINUE	SMT
1211	2220	CONTINUE	SMT
1212	C ---	PRINT SUMMARY QUANTILE PLOT	SMT
1213		WRITE(6,173)	SMT
1214		WRITE(6,161) N,M,D	SMT
1215		WRITE(6,101)	SMT
1216		DO 2191 J=1,50	SMT
1217		K=51-J	SMT
1218		IF(MOD(K,5).NE.0) GO TO 2185	SMT
1219		YLABEL=(K-DLH(2))/VSCALE + YMIN	SMT
1220		WRITE(6,103) YLABEL,(PLOT(I,K),I=1,IWIDTH)	SMT
1221		GO TO 2191	SMT
1222	2185	CONTINUE	SMT
1223		WRITE(6,100) (PLOT(I,K),I=1,IWIDTH)	SMT
1224	2191	CONTINUE	SMT
1225		WRITE(6,106) (XAXIS(I,1),I=1,IWIDTH)	SMT

1226	WRITE(6,104) (XAXIS(I,2),I=1,IWIDTH)	SMT
1227	C --- PRINT QUANTILE AMOUNTS	SMT
1228	WRITE(6,156)	SMT
1229	WRITE(6,147) (NE(I),I=1,L)	SMT
1230	DO 2199 I=1,NSYM	SMT
1231	WRITE(6,167) QVAL(I), (XPVAL(K,I,1),K=1,L)	SMT
1232	2199 CONTINUE	SMT
1233	WRITE(6,158) LABEL(7), (XSTAT(K,7,1),K=1,L1)	SMT
1234	WRITE(6,108) TTL	SMT
1235	C --- \$	SMT
1236	C --- PRINT SUMMARY STATISTICS PAGE	SMT
1237	WRITE(6,171) NSR	SMT
1238	WRITE(6,172) (NE(I),I=1,L)	SMT
1239	WRITE(6,262)	SMT
1240	WRITE(6,157) LABEL(1), (XSTAT(K,1,1), K=1,L)	SMT
1241	WRITE(6,157) BLK, (XSTAT(K,1,2), K=1,L)	SMT
1242	WRITE(6,262)	SMT
1243	WRITE(6,157) LABEL(2), (XSTAT(K,2,1), K=1,L1)	SMT
1244	WRITE(6,157) BLK, (XSTAT(K,2,2), K=1,L1)	SMT
1245	IF(MSE .NE. 1) GO TO 443	SMT
1246	WRITE(6,262)	SMT
1247	WRITE(6,157) LABEL(6), (XSTAT(K,6,1), K=1,L1)	SMT
1248	WRITE(6,157) BLK, (XSTAT(K,6,2), K=1,L1)	SMT
1249	443 CONTINUE	SMT
1250	WRITE(6,262)	SMT
1251	WRITE(6,157) LABEL(4), (XSTAT(K,4,1), K=1,L2)	SMT
1252	WRITE(6,157) BLK, (XSTAT(K,4,2), K=1,L2)	SMT
1253	WRITE(6,262)	SMT
1254	WRITE(6,157) LABEL(5), (XSTAT(K,5,1), K=1,L3)	SMT
1255	WRITE(6,157) BLK, (XSTAT(K,5,2), K=1,L3)	SMT
1256	WRITE(6,262)	SMT
1257	WRITE(6,157) LABEL(7), (XSTAT(K,7,1), K=1,L1)	SMT
1258	WRITE(6,157) BLK, (XSTAT(K,7,2), K=1,L1)	SMT
1259	C --- PRINT QUANTILE STATISTICS	SMT
1260	WRITE(6,169)	SMT
1261	DO 445 I=1,NSYM	SMT
1262	WRITE(6,262)	SMT
1263	WRITE(6,167) QVAL(I), (XPVAL(K,I,1),K=1,L)	SMT
1264	WRITE(6,168) BLK, (XPVAL(K,I,2),K=1,L)	SMT
1265	445 CONTINUE	SMT
1266	C	SMT
1267	DO 350 I=1,6	SMT
1268	XBA(I,1)=GBA(I,1)/NSR	SMT
1269	XBA(I,2)=SQRT((GBA(I,2)-NSR*XBA(I,1)**2)/	SMT
1270	* ((NSR-1)*NSR))	SMT
1271	XBV(I,1)=GBV(I,1)/NSR	SMT
1272	C*** XBV(I,2)=SQRT((GBV(I,2)-NSR*XBV(I,1)**2)/	SMT
1273	C*** * ((NSR-1)*NSR))	SMT
1274	XBS(I,1)=GBS(I,1)/NSR	SMT
1275	XBS(I,2)=SQRT((GBS(I,2)-NSR*XBS(I,1)**2)/	SMT
1276	* ((NSR-1)*NSR))	SMT
1277	XVV(I,1)=GVV(I,1)/NSR	SMT
1278	XVV(I,2)=SQRT((GVV(I,2)-NSR*XVV(I,1)**2)/	SMT
1279	* ((NSR-1)*NSR))	SMT
1280	350 CONTINUE	SMT
1281	C	SMT

1282	IF(D1 .LT. 2) GO TO 410	SMT
1283	WRITE(6,262)	SMT
1284	WRITE(6,151) (XBA(I,1),I=1,D1A)	SMT
1285	WRITE(6,176) (XBA(I,2),I=1,D1A)	SMT
1286	IF(M .LT. 2) GO TO 410	SMT
1287	WRITE(6,262)	SMT
1288	WRITE(6,153) (XBS(I,1),I=1,D1)	SMT
1289	WRITE(6,176) (XBS(I,2),I=1,D1)	SMT
1290	410 CONTINUE	SMT
1291	IF(DT .LT. 2) GO TO 420	SMT
1292	WRITE(6,262)	SMT
1293	WRITE(6,159) (XVV(I,1),I=1,DT)	SMT
1294	WRITE(6,176) (XVV(I,2),I=1,DT)	SMT
1295	420 CONTINUE	SMT
1296	C	SMT
1297	WRITE(6,262)	SMT
1298	WRITE(6,108) TTL	SMT
1299	C --- PERCENTILE PLOT	SMT
1300	IF(IPR .EQ. 1) CALL PRPLOT(M,N,NSR,L,NE,D,VMX,VXCNT,PLOT,TTL,	SMT
1301	* XAXIS,LOCX)	SMT
1302	C	SMT
1303	100 FORMAT(9X,' ',122A1,' ')	SMT
1304	101 FORMAT(9X,'+',122('-',),'+')	SMT
1305	102 FORMAT('1')	SMT
1306	103 FORMAT(' ',G8.2,'-',122A1,' ')	SMT
1307	104 FORMAT(10X,122A1)	SMT
1308	106 FORMAT(9X,'+',122A1,'+')	SMT
1309	107 FORMAT(10G13.8)	SMT
1310	108 FORMAT(/,' ESTIMATOR: ',A120)	SMT
1311	151 FORMAT(/,' MEAN OF REGRESSION ON AVERAGES',6G17.4)	SMT
1312	176 FORMAT(' ',6G17.4)	SMT
1313	152 FORMAT(' VARIANCE OF REGRESSION',8X,6G17.4)	SMT
1314	153 FORMAT(' STD DEV OF REGRESSION',9X,6G17.4)	SMT
1315	156 FORMAT(/' SUBSAMPLE')	SMT
1316	146 FORMAT(' SIZE ',8(18,6X),/)	SMT
1317	147 FORMAT(' SIZE ',8(18,6X),/' QUANTILE',/)	SMT
1318	167 FORMAT(1X,F5.3,6X,8G14.4)	SMT
1319	168 FORMAT(1X,A8,3X, 8G14.4)	SMT
1320	169 FORMAT(/' QUANTILES')	SMT
1321	157 FORMAT(1X,A8,3X,8G14.4)	SMT
1322	158 FORMAT(1X,A8,8F14.4)	SMT
1323	159 FORMAT(/' REGRESSION ON VARIANCE',7X,6G17.4)	SMT
1324	161 FORMAT(9X,'SAMPLE SIZE (N):',I5,20X,'NO. OF REPLICATIONS (M):',	SMT
1325	+I5,18X,'DEGREE OF REGRESSION (D):',I3)	SMT
1326	162 FORMAT(/)	SMT
1327	171 FORMAT('1',30X,'SUMMARY STATISTICS (MEAN/STD)',	SMT
1328	* I8,' SUPER-REPLICATIONS')	SMT
1329	172 FORMAT(/,' SUBSAMPLE',/,' SIZE ',8(18,6X),/)	SMT
1330	173 FORMAT('1',30X,'SUMMARY QUANTILE PLOT FOR ALL SUPER-REPLICATIONS')	SMT
1331	262 FORMAT(' ')	SMT
1332	201 FORMAT(1X,'VERTICAL SCALE: YMIN =',F10.4,/,18X,'YMAX =',F10.4/)	SMT
1333	202 FORMAT('1',40X,'QUANTILE PLOT')	SMT
1334	203 FORMAT('1',40X,'NORMALIZED QUANTILE PLOT')	SMT
1335	END	

1336	SUBROUTINE SETCOLR(I)	
1337	WRITE(6,1)I	
1338 1	FORMAT(' +?r',I1)	
1339	RETURN	
1340	END	
1341	SUBROUTINE CLRCOLR(COLRPLT)	SMT
1342	CHARACTER COLRPLT(122,50,5)*1	SMT
1343	DO 1 I=1,122	
1344	DO 1 J=1,50	
1345	DO 1 K=1,5	
1346 1	COLRPLT(I,J,K) = ' '	
1347	RETURN	
1348	END	
1349 C---		SMT
1350	SUBROUTINE CMPSUM(BA,BV,BS,V,DT,D1,L,STAT,PVAL,NSYM,	SMT
1351	* GBA,GBV,GBS,GVV,GSTAT,GPVAL)	SMT
1352 C ---	ACCUMULATE SUMMARY STATISTICS: GBA,GBV,GBS,GVV,GSTAT,GPVAL	SMT
1353	REAL*4 STAT(8,7),PVAL(8,11)	SMT
1354	REAL*4 V(7),BA(7),BV(7),BS(7)	SMT
1355	REAL*8 GSTAT(8,7,2), GPVAL(8,11,2)	SMT
1356	REAL*8 GBA(7,2), GBV(7,2), GBS(7,2), GVV(7,2)	SMT
1357	INTEGER L,DT,D1,NSYM	SMT
1358	IF(D1.LT.2 .OR. DT.LT.2) GO TO 113	SMT
1359	DO 300 I=1,6	SMT
1360	GBA(I,1)=GBA(I,1) + BA(I)	SMT
1361	GBA(I,2)=GBA(I,2) + BA(I)**2	SMT
1362	GBV(I,1)=GBV(I,1) + BV(I)	SMT
1363	GBV(I,2)=GBV(I,2) + BV(I)**2	SMT
1364	GBS(I,1)=GBS(I,1) + BS(I)	SMT
1365	GBS(I,2)=GBS(I,2) + BS(I)**2	SMT
1366	IF(I .LE. DT) THEN	SMT
1367	GVV(I,1)=GVV(I,1) + V(I)	SMT
1368	GVV(I,2)=GVV(I,2) + V(I)**2	SMT
1369	ENDIF	SMT
1370	300 CONTINUE	SMT
1371	113 CONTINUE	SMT
1372	DO 310 I=1,L	SMT
1373	DO 320 J=1,7	SMT
1374	GSTAT(I,J,1)=GSTAT(I,J,1) + STAT(I,J)	SMT
1375	GSTAT(I,J,2)=GSTAT(I,J,2) + STAT(I,J)**2	SMT
1376	320 CONTINUE	SMT
1377	310 CONTINUE	SMT
1378 C ---	COMPUTE SUMMARY FOR QUANTILES	SMT
1379	DO 1221 K=1,L	SMT
1380	DO 1241 IS=1,NSYM	SMT
1381	GPVAL(K,IS,1)=GPVAL(K,IS,1) + PVAL(K,IS)	SMT
1382	GPVAL(K,IS,2)=GPVAL(K,IS,2) + PVAL(K,IS)**2	SMT
1383	1241 CONTINUE	SMT
1384	1221 CONTINUE	SMT
1385	END	SMT
1386 C ---		SMT
1387	SUBROUTINE COEFF(B,M,D1A, BA,BV,BS,V)	SMT
1388 C ---	COMPUTE REGRESSION COEFFICIENTS, VARS, ETC: BA,BV,BS,V	SMT

1389	REAL*4 V(7),BA(7),BV(7),BS(7), B(7,100)	SMT
1390	INTEGER D1A	SMT
1391	AM=M	SMT
1392	DO 93 I=1,7	SMT
1393	BA(I)=0	SMT
1394	BV(I)=0	SMT
1395	BS(I)=0	SMT
1396	V(I)=0	SMT
1397	93 CONTINUE	SMT
1398	DO 94 I=1,D1A	SMT
1399	DO 95 J=1,M	SMT
1400	BA(I)=BA(I)+B(I,J)	SMT
1401	BV(I)=BV(I)+B(I,J)**2	SMT
1402	95 CONTINUE	SMT
1403	BA(I)=BA(I)/AM	SMT
1404	IF(M.EQ.1)GO TO 94	SMT
1405	BV(I)=(BV(I)-AM*BA(I)**2)/(AM*(AM-1.))	SMT
1406	IF(BV(I).LT. 0.) BV(I)=0	SMT
1407	BS(I)=BV(I)**.5	SMT
1408	94 CONTINUE	SMT
1409	END	SMT
1410	C ---	SMT
1411	SUBROUTINE CMPMOM(Y,KP,VMSE,MSE,K, STAT,SVAR)	SMT
1412	C --- COMPUTE MOMENT ESTIMATES IN STAT(K,*) AND SVAR(K)	SMT
1413	REAL Y(1), VMSE(8), STAT(8,7), SVAR(8)	SMT
1414	REAL*8 XMEAN,DEV,SUM2,SUM3,SUM4	SMT
1415	XMEAN=0.	SMT
1416	DO 180 IM1=1,KP	SMT
1417	XMEAN=XMEAN+Y(IM1)	SMT
1418	180 CONTINUE	SMT
1419	XMEAN=XMEAN/FLOAT(KP)	SMT
1420	SUM2 = 0.0D0	SMT
1421	SUM3 = 0.0D0	SMT
1422	SUM4 = 0.0D0	SMT
1423	DO 190 IP1=1,KP	SMT
1424	DEV = Y(IP1) - XMEAN	SMT
1425	SUM2 = SUM2 + DEV * DEV	SMT
1426	SUM3 = SUM3 + DEV ** 3	SMT
1427	SUM4 = SUM4 + DEV ** 4	SMT
1428	190 CONTINUE	SMT
1429	C	SMT
1430	C CHECK TO INSURE SAMPLE SIZE IS LARGE ENOUGH FOR EACH MOMENT	SMT
1431	C CLEAR STAT	SMT
1432	DO 419 IP1=1,7	SMT
1433	STAT(K,IP1)=0.	SMT
1434	419 CONTINUE	SMT
1435	IF (KP.LT.2) GO TO 9	SMT
1436	VAR = SUM2 / (KP - 1.0)	SMT
1437	STDV = SQRT(VAR)	SMT
1438	C --- SERIAL CORRELATION	SMT
1439	SERCOR=0.	SMT
1440	DO 421 IP1=2,KP	SMT
1441	SERCOR=SERCOR + (Y(IP1-1)-XMEAN)*(Y(IP1)-XMEAN)	SMT
1442	421 CONTINUE	SMT
1443	SERCOR=SERCOR/((KP-1)*VAR)	SMT

1444	7 IF (KP.LT.3) GO TO 9	SMT
1445	SUM3 = SUM3 * KP /((KP-1.) * (KP-2.))	SMT
1446	SKEW = SUM3 / STDV ** 3	SMT
1447	8 IF (KP.LT.4) GO TO 9	SMT
1448	SUM4 = SUM4*((KP-2.)*KP+3.)/((KP-1.)*(KP-2.)*(KP-3.))	SMT
1449	SUM4 = SUM4 - VAR*VAR*3.*(KP-1.)*(KP+KP-3.)/(KP*(KP-2.)*(KP-3.))	SMT
1450	CKURT = SUM4 / (VAR * VAR) - 3.	SMT
1451	9 STAT(K,1)=XMEAN	SMT
1452	STAT(K,2)=STDV	SMT
1453	STAT(K,3)=STDV/SQRT(FLOAT(KP))	SMT
1454	STAT(K,4)=SKEW	SMT
1455	STAT(K,5)=CKURT	SMT
1456	C --- MEAN SQUARE ERROR 05-25-86	SMT
1457	IF(MSE .EQ. 1) THEN	SMT
1458	STAT(K,6)=SQRT(VAR + (XMEAN-VMSE(K))**2)	SMT
1459	ELSE	SMT
1460	STAT(K,6)=0.	SMT
1461	ENDIF	SMT
1462	SVAR(K)=VAR	SMT
1463	STAT(K,7)=SERCOR	SMT
1464	END	SMT
1465	C---	SMT
1466	SUBROUTINE PRPLOT(M,N,NSR,L,NE,D,VMX,VXCNT,PLOT,TTL,XAXIS,LOCX)	SMT
1467	C --- PRINT PERCENTILE PLOTS 09-09-86	SMT
1468	REAL*4 VMX(8,4),VXCNT(8,4), VXSTD(8,4)	SMT
1469	REAL*4 ULH(4),DLH(4)	SMT
1470	INTEGER NE(8), LOCX(8)	SMT
1471	CHARACTER*120 TTL	SMT
1472	CHARACTER*1 SYM(4), PLOT(122,50), XAXIS(122,2)	SMT
1473	DATA DLH/1.,1.,122.,50./, SYM/'*', '#', '@', '&'/	SMT
1474	C CLEAR PLOT ARRAY	SMT
1475	CALL CLRPA(PLOT)	SMT
1476	C SET HORIZONTAL XMIN, XMAX	SMT
1477	ULH(1)=.7*NE(1)	SMT
1478	ULH(3)=1.2*NE(L)	SMT
1479	ULH(2)=0.	SMT
1480	ULH(4)=1.	SMT
1481	XMIN=ULH(1)	SMT
1482	XMAX=ULH(3)	SMT
1483	YMIN=ULH(2)	SMT
1484	YMAX=ULH(4)	SMT
1485	IWIDTH=DLH(3)	SMT
1486	C --- SCALING FACTORS	SMT
1487	VSCALE=(DLH(4)-DLH(2))/(ULH(4)-ULH(2))	SMT
1488	C	SMT
1489	C --- CONVERT FREQUENCY COUNTS TO PROBS. FOR PLOT & VARS FOR PRINTING	SMT
1490	DO 10 I=1,8	SMT
1491	NBK=N/NE(I)	SMT
1492	AN=NSR*M*NBK	SMT
1493	DO 20 J=1,4	SMT
1494	P=VXCNT(I,J)/AN	SMT
1495	VXCNT(I,J)=P	SMT
1496	IQ=(P - ULH(2))*VSCALE + 1	SMT
1497	IQ=MIN(IQ, 50)	SMT
1498	IK=LOCX(I)+J-2	SMT

1499	DO 21 K=1,IQ	SMT
1500	PLOT(IK, K)=SYM(J)	SMT
1501	21 CONTINUE	SMT
1502	VXSTD(I,J)=SQRT(P*(1-P)/AN)	SMT
1503	20 CONTINUE	SMT
1504	10 CONTINUE	SMT
1505	C --- PRINT PERCENTILE PLOT	SMT
1506	WRITE(6,173) NSR	SMT
1507	WRITE(6,161) N,M,D	SMT
1508	WRITE(6,101)	SMT
1509	DO 2191 J=1,50	SMT
1510	K=51-J	SMT
1511	IF(MOD(K,5).NE.0) GO TO 2185	SMT
1512	YLABEL=(K-DLH(2))/VSCALE + ULH(2)	SMT
1513	WRITE(6,103) YLABEL,(PLOT(I,K),I=1,IWIDTH)	SMT
1514	GO TO 2191	SMT
1515	2185 CONTINUE	SMT
1516	WRITE(6,100) (PLOT(I,K),I=1,IWIDTH)	SMT
1517	2191 CONTINUE	SMT
1518	WRITE(6,106) (XAXIS(I,1),I=1,IWIDTH)	SMT
1519	WRITE(6,104) (XAXIS(I,2),I=1,IWIDTH)	SMT
1520	WRITE(6,156)	SMT
1521	WRITE(6,146) (NE(I),I=1,L)	SMT
1522	C --- PRINT VARIANCES	SMT
1523	DO 50 J=1,4	SMT
1524	WRITE(6,150) J, (VMX(I,J), I=1,L)	SMT
1525	WRITE(6,151) (VXCNT(I,J), I=1,L)	SMT
1526	WRITE(6,152) (VXSTD(I,J), I=1,L)	SMT
1527	50 CONTINUE	SMT
1528	WRITE(6,108) TTL	SMT
1529	100 FORMAT(9X,' ',122A1,' ')	SMT
1530	101 FORMAT(9X,'+',122(' - '),'+')	SMT
1531	102 FORMAT('1')	SMT
1532	103 FORMAT(' ',G8.2,' - ',122A1,' ')	SMT
1533	104 FORMAT(10X,122A1)	SMT
1534	106 FORMAT(9X,'+',122A1,'+')	SMT
1535	108 FORMAT(/, ESTIMATOR: ',A120)	SMT
1536	146 FORMAT(SIZE ',8(I8,6X))	SMT
1537	150 FORMAT(/, X-VALUE-',I2, 8G15.4)	SMT
1538	151 FORMAT(PERCENTILE', 8G15.4)	SMT
1539	152 FORMAT(ESTIM. STD', 8G15.4)	SMT
1540	156 FORMAT(/ SUBSAMPLE')	SMT
1541	161 FORMAT(9X, SAMPLE SIZE (N): ',I5,20X, NO. OF REPLICATIONS (M): ',	SMT
1542	+I5,18X, DEGREE OF REGRESSION (D): ',I3)	SMT
1543	173 FORMAT('1',30X, PERCENTILE PLOTS FOR FOUR X-VALUES',I8,	SMT
1544	* ' SUPER-REPLICATIONS',/)	SMT
1545	END	SMT
1546	C -----	SMT
1547	SUBROUTINE CLRGT(GBA,GBV,GBS,GVV,GSTAT,GPVAL)	SMT
1548	C --- CLEAR GRANDTOTALS	SMT
1549	REAL*8 GPVAL(8,11,2)	SMT
1550	REAL*8 GBA(7,2), GBV(7,2), GBS(7,2), GV(7,2), GSTAT(8,7,2)	SMT
1551	DO 41 I=1,7	SMT
1552	DO 42 J=1,2	SMT
1553	GBA(I,J)=0	SMT

1554		GBV(I,J)=0	SMT
1555		GBS(I,J)=0	SMT
1556		GVV(I,J)=0	SMT
1557	42	CONTINUE	SMT
1558	41	CONTINUE	SMT
1559		DO 43 I=1,8	SMT
1560		DO 44 J=1,7	SMT
1561		GSTAT(I,J,1)=0	SMT
1562		GSTAT(I,J,2)=0	SMT
1563	44	CONTINUE	SMT
1564		DO 46 J=1,11	SMT
1565		GPVAL(I,J,1)=0	SMT
1566		GPVAL(I,J,2)=0	SMT
1567	46	CONTINUE	SMT
1568	43	CONTINUE	SMT
1569		END	SMT
1570	C		SMT
1571		SUBROUTINE CLRPA(PLOT)	SMT
1572		CHARACTER*1 PLOT(122,50),BLK	SMT
1573		DATA BLK/' '/	SMT
1574		DO 3 J=1,50	SMT
1575		DO 4 I=1,122	SMT
1576		PLOT(I,J)=BLK	SMT
1577	4	CONTINUE	SMT
1578	3	CONTINUE	SMT
1579		END	SMT
1580	C*****		SMT
1581	C		SMT
1582		SUBROUTINE BOXPRT(Y,NY,IX,PLOT,RG,XMIN,YMIN,XMAX,YMAX,VSCALE)	SMT
1583	C	PREPARES BOXPLOT FROM VECTOR Y (IN 2-D ARRAY PLOT)	SMT
1584		CHARACTER*1 PLOT(122,50),DASH,CBAR,CROSS,CSTR,CO	SMT
1585		REAL Y(NY)	SMT
1586		INTEGER RG	SMT
1587		LOGICAL LFLAG	SMT
1588		DATA DASH/'-'/,CBAR/' '/,CSTR/'*'/,CROSS/'+'/,CO/'0'/	SMT
1589		IF(NY .GE. 9) GO TO 5	SMT
1590	C	WHEN LESS THAN 9 POINTS JUST SHOW THE POINTS	SMT
1591		DO 8 I=1,NY	SMT
1592		J=(Y(I)-YMIN)*VSCALE + 1.	SMT
1593	C	IGNORE VALUE IF IT FALLS OUTSIDE WINDOW	SMT
1594		IF(J.GT.50 .OR. J.LT.1) GO TO 8	SMT
1595		PLOT(IX,J)=CO	SMT
1596	8	CONTINUE	SMT
1597		SUM=0.	SMT
1598		DO 88 I=1,NY	SMT
1599		SUM=SUM+Y(I)	SMT
1600	88	CONTINUE	SMT
1601		SUM=SUM/FLOAT(NY)	SMT
1602		MEAN=(SUM-YMIN)*VSCALE+1	SMT
1603		IF(MEAN.LE.50 .AND. MEAN.GE.1) PLOT(IX,MEAN)=CSTR	SMT
1604		GO TO 99	SMT
1605	5	CONTINUE	SMT
1606		LFLAG=.FALSE.	SMT
1607		P25 =PCTL(Y,NY,.25,0)	SMT

1608	P75 =PCTL(Y,NY,.75,1)	SMT
1609	P50 =PCTL(Y,NY,.50,1)	SMT
1610	IQ1=(P25-YMIN)*VSCALE+1.	SMT
1611	IQ2=(P50-YMIN)*VSCALE+1.	SMT
1612	IQ3=(P75-YMIN)*VSCALE+1.	SMT
1613	XLOW=2*P25-P75	SMT
1614	ILOW=(XLOW-YMIN)*VSCALE+1.	SMT
1615	XHI=2*P75-P25	SMT
1616	IHI=(XHI-YMIN)*VSCALE+1.	SMT
1617	CLOW=2.5*P25-1.5*P75	SMT
1618	CHI=2.5*P75-1.5*P25	SMT
1619 C	DRAW BOX	SMT
1620	DO 20 J=IQ1,IQ3	SMT
1621	IF(J.GT.50 .OR. J.LT.1) GO TO 20	SMT
1622	PLOT(IX-1,J)=CBAR	SMT
1623	PLOT(IX+1,J)=CBAR	SMT
1624	20 CONTINUE	SMT
1625	IF(IQ1.GT.50 .OR. IQ1.LT.1) GO TO 21	SMT
1626	PLOT(IX-1,IQ1)=DASH	SMT
1627	PLOT(IX+1,IQ1)=DASH	SMT
1628	21 CONTINUE	SMT
1629	IF(IQ3.GT.50 .OR. IQ3.LT.1) GO TO 22	SMT
1630	PLOT(IX-1,IQ3)=DASH	SMT
1631	PLOT(IX+1,IQ3)=DASH	SMT
1632	22 CONTINUE	SMT
1633 C	DETERMINE IF OUTLIERS ARE TO BE COUNTED AND THE NUMBER PRINTED.	SMT
1634	IF(RG.EQ.1) GO TO 55	SMT
1635	DO 30 I=1,NY	SMT
1636	J=(Y(I)-YMIN)*VSCALE+1.	SMT
1637 C	IGNORE VALUE IF IT FALLS OUTSIDE WINDOW	SMT
1638	IF(J.GT.50 .OR. J.LT.1) GO TO 30	SMT
1639	IF(Y(I).LT.CLOW) PLOT(IX,J)=CSTR	SMT
1640	IF(Y(I).LT.CLOW) GO TO 30	SMT
1641	IF(Y(I).GE.CLOW .AND. Y(I).LT.XLOW) PLOT(IX,J)=CO	SMT
1642	IF(LFLAG .OR. Y(I).LT.XLOW) GO TO 25	SMT
1643 C	THIS IS THE LOW-CROSS POINTER (1ST POINT GE XLOW)	SMT
1644	LFLAG=.TRUE.	SMT
1645	ILX=J	SMT
1646 C	NEXT LINE ENDS UP WITH HI-CROSS POINTER (LAST POINT LE XHI)	SMT
1647	25 IF(Y(I).LE.XHI) IHX=J	SMT
1648	IF(Y(I).GT.XHI .AND. Y(I).LE.CHI) PLOT(IX,J)=CO	SMT
1649	IF(Y(I).GT.CHI) PLOT(IX,J)=CSTR	SMT
1650	30 CONTINUE	SMT
1651	GO TO 56	SMT
1652 C		SMT
1653 C	SCALE TO INTERQUARTILE +(-) INTERQUARTILE DISTANCE.	SMT
1654 C		SMT
1655	55 II=0	SMT
1656	III=0	SMT
1657	DO 31 I=1,NY	SMT
1658	J=(Y(I)-YMIN)*VSCALE+1.	SMT
1659	IF(Y(I).LT.CLOW) II = II+1	SMT
1660	IF(Y(I).GT.CHI) III=III+1	SMT
1661	IF(J.GT.50 .OR. J.LT.1) GO TO 31	SMT
1662	IF(Y(I).GE.CLOW .AND. Y(I).LT.XLOW) PLOT(IX,J)=CO	SMT
1663	IF(LFLAG .OR. Y(I).LT.XLOW) GO TO 26	SMT

1664 C	THIS IS THE LOW-CROSS POINTER (1ST POINT GE XLOW)	SMT
1665	LFLAG=. TRUE.	SMT
1666	ILX=J	SMT
1667 C	NEXT LINE ENDS UP WITH HI-CROSS POINTER (LAST POINT LE XHI)	SMT
1668	26 IF(Y(I). LE. XHI) IHX=J	SMT
1669	IF(Y(I). GT. XHI . AND. Y(I). LE. CHI) PLOT(IX,J)=CO	SMT
1670	31 CONTINUE	SMT
1671 C		SMT
1672 C	PRINT NUMBER OF OUTLIERS UNLESS 0.	SMT
1673	DO 36 K=1,2	SMT
1674	IK=II	SMT
1675	J=(CLOW-YMIN)*VSCALE + 1	SMT
1676	IF(K. EQ. 2) IK=III	SMT
1677	IF(K. EQ. 2) J=(CHI-YMIN)*VSCALE + 1	SMT
1678	IF(J. LT. 1) J=1	SMT
1679	IF(J. GT. 50) J=50	SMT
1680	IF (IK. EQ. 0) GO TO 36	SMT
1681	CALL NUMPRT(IX,J,IK,PLOT)	SMT
1682	36 CONTINUE	SMT
1683 C		SMT
1684 C	FILL BARS ABOVE AND BELOW THE BOX	SMT
1685	56 DO 32 J=ILX,IQ1	SMT
1686	IF(J. GT. 50 . OR. J. LT. 1) GO TO 32	SMT
1687	PLOT(IX,J)=CBAR	SMT
1688	32 CONTINUE	SMT
1689	DO 33 J=IQ3,IHX	SMT
1690	IF(J. GT. 50 . OR. J. LT. 1) GO TO 33	SMT
1691	PLOT(IX,J)=CBAR	SMT
1692	33 CONTINUE	SMT
1693	IF(ILX. LE. 50 . AND. ILX. GE. 1) PLOT(IX,ILX)=CROSS	SMT
1694	IF(IHX. LE. 50 . AND. IHX. GE. 1) PLOT(IX,IHX)=CROSS	SMT
1695	IF(IQ1. LE. 50 . AND. IQ1. GE. 1) PLOT(IX,IQ1)=DASH	SMT
1696	IF(IQ2. LE. 50 . AND. IQ2. GE. 1) PLOT(IX,IQ2)=CROSS	SMT
1697	IF(IQ3. LE. 50 . AND. IQ3. GE. 1) PLOT(IX,IQ3)=DASH	SMT
1698	SUM=0.	SMT
1699	DO 40 I=1,NY	SMT
1700	SUM=SUM+Y(I)	SMT
1701	40 CONTINUE	SMT
1702	SUM=SUM/FLOAT(NY)	SMT
1703	MEAN=(SUM-YMIN)*VSCALE+1	SMT
1704	IF(MEAN. LE. 50 . AND. MEAN. GE. 1) PLOT(IX,MEAN)=CSTR	SMT
1705	99 CONTINUE	SMT
1706	RETURN	SMT
1707	END	SMT
1708 C	*****	SMT
1709	SUBROUTINE RREG(XS,YS,BS,M,N,IX1,IX2)	SMT
1710 C	ROBUST REGRESSION ON Y=X*B	SMT
1711 C	X=M BY N MATRIX CONTAINED IN AN ARRAY OF DIM(IX1,IX2)	SMT
1712 C	Y=M-VECTOR CONTAINED IN AN ARRAY OF DIM(IX1)	SMT
1713 C	B=N-VECTOR CONTAINED IN AN ARRAY OF DIM(IX2)	SMT
1714 C	XX,XXI=WORK ARRAYS OF DIM(IX2,IX2)	SMT
1715 C	WY=WORK ARRAY OF DIM(IX1)	SMT
1716 C	WX=WORK MATRIX OF DIM(IX1,IX2)	SMT
1717 C	XY=WORK ARRAY OF DIM(IX2)	SMT
1718 C	WK=WORK ARRAY OF DIM(N**2 + 3*N) OR LARGER	SMT

1719	C	***** +++++ +++++ MODIFICATION USING CHOLESKY +++++	SMT
1720	C		SMT
1721		REAL*4 YS(8),XS(8,7),BS(7)	SMT
1722		REAL*8 Y(8),X(8,7),B(7),XTX(7,7),XTY(7)	SMT
1723	C	***** CONVERT REAL*4 TO REAL*8 *****	SMT
1724		DO 10 I=1,IX1	SMT
1725		Y(I)=DBLE(YS(I))	SMT
1726		DO 5 J=1,IX2	SMT
1727		X(I,J)=DBLE(XS(I,J))	SMT
1728	5	CONTINUE	SMT
1729	10	CONTINUE	SMT
1730	C		SMT
1731		CALL MATSQ (X,XTX,M,N)	SMT
1732		CALL MATMUL (X,Y,XTY,M,N)	SMT
1733		CALL CHOLES (XTX,XTY,B,N)	SMT
1734	C		SMT
1735	C	***** CONVERT REAL*8 TO REAL*4 *****	SMT
1736	C	DO 20 I=1,IX1	SMT
1737	C	YS(I)=SNGL(Y(I))	SMT
1738		DO 15 J=1,IX2	SMT
1739		BS(J)=SNGL(B(J))	SMT
1740	C	XS(I,J)=SNGL(X(I,J))	SMT
1741	15	CONTINUE	SMT
1742	20	CONTINUE	SMT
1743	C		SMT
1744		RETURN	SMT
1745		END	SMT
1746	C	*****	SMT
1747		SUBROUTINE NUMPRT(IX,J,IK,PLOT)	SMT
1748	C	NUMPRT PLOTS THE NUMBER IK IN THE 2-D ARRAY PLOT CENTERED ON	SMT
1749	C	THE PLOT(IX,J) POSITION.	SMT
1750	C	IX = COLUMN OF MATRIX PLOT WHERE NUMBER IS TO BE PRINTED.	SMT
1751	C	J = ROW OF MATRIX WHERE NUMBER IS TO BE PRINTED.	SMT
1752	C	IK = NUMBER TO BE PRINTED	SMT
1753	C	PLOT = 2-D ARRAY WHERE NUMBER IS TO BE PLOTTED.	SMT
1754	C		SMT
1755		CHARACTER*1 NUM(10),PLOT(122,J)	SMT
1756		DATA NUM/'0','1','2','3','4','5','6','7','8','9'/	SMT
1757		IF (IK.LT.10) GO TO 1	SMT
1758		IF (IK.LT.100) GO TO 2	SMT
1759		IF (IK.LT.1000) GO TO 3	SMT
1760		IF (IK.LT.10000) GO TO 4	SMT
1761		I10000 = IK/10000	SMT
1762		PLOT(IX-2,J) = NUM(I10000+1)	SMT
1763		I1000 = (IK-I10000*10000)/1000	SMT
1764		PLOT(IX-1,J) = NUM(I1000+1)	SMT
1765		I100 = (IK-I10000*10000-I1000*1000)/100	SMT
1766		PLOT(IX,J) = NUM(I100+1)	SMT
1767		I10 = (IK-I10000*10000-I1000*1000-I100*100)/10	SMT
1768		PLOT(IX+1,J) = NUM(I10+1)	SMT
1769		I1 = (IK-I10000*10000-I1000*1000-I100*100-I10*10)	SMT
1770		PLOT(IX+2,J) = NUM(I1+1)	SMT
1771		GO TO 22	SMT
1772	4	I10000 = IK/1000	SMT
1773		PLOT(IX-2,J) = NUM(I1000+1)	SMT

1774	I100 = (IK-I1000*1000)/100	SMT
1775	PLOT(IX-1,J) = NUM(I100+1)	SMT
1776	I10 = (IK-I1000*1000-I100*100)/10	SMT
1777	PLOT(IX,J) = NUM(I10+1)	SMT
1778	I1 = (IK-I1000*1000-I100*100-I10*10)	SMT
1779	PLOT(IX+1,J) = NUM(I1+1)	SMT
1780	GO TO 22	SMT
1781	3 I100 = IK/100	SMT
1782	PLOT(IX-1,J) = NUM(I100+1)	SMT
1783	I10 = (IK-I100*100)/10	SMT
1784	PLOT(IX,J) = NUM(I10+1)	SMT
1785	I1 = (IK-I100*100-I10*10)	SMT
1786	PLOT(IX+1,J) = NUM(I1+1)	SMT
1787	GO TO 22	SMT
1788	2 I10 = IK/10	SMT
1789	PLOT(IX-1,J) = NUM(I10+1)	SMT
1790	I1 = (IK-I10*10)	SMT
1791	PLOT(IX,J) = NUM(I1+1)	SMT
1792	GO TO 22	SMT
1793	1 PLOT(IX,J) = NUM(IK+1)	SMT
1794	22 RETURN	SMT
1795	END	SMT

1796	C*****	SMT
1797	C	SMT
1798	SUBROUTINE SECEST(GENEST,IX,N,M,NEK,Y,KP)	SMT
1799	REAL Y(1)	SMT
1800	real*8 IX	SMT
1801	C COMPUTE ESTIMATES "EST" FOR SECTION LENGTH NEK (LIMITED TO 1000)	SMT
1802	NBK=N/NEK	SMT
1803	KP=0	SMT
1804	DO 10 I=1,M	SMT
1805	DO 15 J=1,NBK	SMT
1806	KP=KP+1	SMT
1807	CALL GENEST(IX,NEK,Y(KP))	SMT
1808	15 CONTINUE	SMT
1809	10 CONTINUE	SMT
1810	RETURN	SMT
1811	END	SMT

1812	C*****	SMT
1813	C	SMT
1814	SUBROUTINE MAXMIN(Y,N,YMAX,YMIN)	SMT
1815	C RETURNS MAX AND MIN VALUES OF VECTOR Y OF LENGTH N	SMT
1816	REAL Y(N)	SMT
1817	YMAX=Y(1)	SMT
1818	YMIN=Y(1)	SMT
1819	DO 605 J=1,N	SMT
1820	IF(Y(J).LT. YMIN) YMIN=Y(J)	SMT
1821	IF(Y(J).GT. YMAX) YMAX=Y(J)	SMT
1822	605 CONTINUE	SMT
1823	RETURN	SMT
1824	END	SMT

1825	C*****	SMT
1826	C	SMT

1827	FUNCTION PCTL(Y,N,P,IC)	SMT
1828 C	COMPUTES P PERCENTILE OF N VALUES IN Y.	SMT
1829 C	WHEN IC=1 DATA IS ALREADY SORTED	SMT
1830	REAL Y(N)	SMT
1831	R=P*FLOAT(N+1)	SMT
1832	IF(IC .NE. 1) CALL SORT(Y,N)	SMT
1833	I=MAXO(INT(R) , 1)	SMT
1834	I=MINO(I,N)	SMT
1835	J=MINO(INT(R+1.) , N)	SMT
1836	R=R-INT(R)	SMT
1837	PCTL=Y(I)+R*(Y(J)-Y(I))	SMT
1838	RETURN	SMT
1839	END	SMT
1840 C	*****	SMT
1841	SUBROUTINE DELETO(Y,KP,YMAX,YMIN)	SMT
1842 C	SUBROUTINE SCALES THE GRAPH TO UPPER (LOWER) QUANTILE + (-)	SMT
1843 C	1.5 TIMES INTERQUARTILE DISTANCE OR TO FIRST POINT WITHIN	SMT
1844 C	THESE LIMITS IF NO POINTS EXIST OUTSIDE.	SMT
1845	REAL Y(KP)	SMT
1846	P25 =PCTL(Y,KP,.25,0)	SMT
1847	P75 =PCTL(Y,KP,.75,1)	SMT
1848	P50 =PCTL(Y,KP,.50,1)	SMT
1849	YMIN=2.5*P25-1.5*P75	SMT
1850	YMAX=2.5*P75-1.5*P25	SMT
1851	IF(Y(1).GT.YMIN) YMIN=Y(1)	SMT
1852	IF(Y(KP).LT.YMAX) YMAX=Y(KP)	SMT
1853	RETURN	SMT
1854	END	SMT
1855 C	*****	SMT
1856 C	CHOLESKI'S METHODE *****	SMT
1857	SUBROUTINE CHOLES (XTX,XTY,BHAT,N)	SMT
1858	REAL*8 L(7,7),SUM,LT(7,7),XTX(7,7),XTY(7),BHAT(7),WY(7)	SMT
1859	REAL*4 B(7)	SMT
1860	INTEGER P	SMT
1861 C		SMT
1862 C	***** INIT L *****	SMT
1863	DO 100 I=1,N	SMT
1864	BHAT(I)=0.0D0	SMT
1865	DO 50 J=1,N	SMT
1866	L(I,J)=0.0D0	SMT
1867	LT(I,J)=0.0D0	SMT
1868	50 CONTINUE	SMT
1869	100 CONTINUE	SMT
1870 C	***** ALGORITHM DECOMPOSITION *****	SMT
1871	L(1,1)=DSQRT(XTX(1,1))	SMT
1872	DO 500 K=2,N	SMT
1873	KK=K-1	SMT
1874	DO 200 J=1,KK	SMT
1875	JJ=J-1	SMT
1876	SUM=0.0D0	SMT
1877	IF (J.EQ.1) GO TO 150	SMT
1878	DO 140 P=1,JJ	SMT
1879	SUM=SUM+(L(K,P)*L(J,P))	SMT
1880	140 CONTINUE	SMT

1881	150	CONTINUE	SMT
1882		L(K,J)=(XTX(K,J)-SUM)/L(J,J)	SMT
1883	200	CONTINUE	SMT
1884		SUM=0.0D0	SMT
1885		DO 300 P=1, KK	SMT
1886		SUM=SUM+(L(K,P)**2)	SMT
1887	300	CONTINUE	SMT
1888		L(K,K)= DSQRT (XTX(K,K)-SUM)	SMT
1889	500	CONTINUE	SMT
1890	C	BUILD L-TRANSPOSE IN LT *****	SMT
1891		DO 540 I=1, N	SMT
1892		DO 530 J=1, N	SMT
1893		LT(I,J)=L(J,I)	SMT
1894	530	CONTINUE	SMT
1895	540	CONTINUE	SMT
1896	C		SMT
1897	C	***** A L G O R I T H M PART 1 A. 2 *****	SMT
1898	C	*** L * WY = XTY	SMT
1899		WY(1)=XTY(1)/L(1,1)	SMT
1900		DO 700 I=2, N	SMT
1901		II=I-1	SMT
1902		SUM=0.0D0	SMT
1903		DO 600 J=1, II	SMT
1904		SUM=SUM+(WY(J)*L(I,J))	SMT
1905	600	CONTINUE	SMT
1906		WY(I)=(XTY(I)-SUM)/L(I,I)	SMT
1907	700	CONTINUE	SMT
1908	C		SMT
1909	C	*** LT * BHAT = WY *****	SMT
1910		BHAT(N)=WY(N)/LT(N,N)	SMT
1911		DO 800 II=2, N	SMT
1912		I=N-II+1	SMT
1913		SUM=0.0D0	SMT
1914		DO 750 J=1, N	SMT
1915		SUM=SUM+(BHAT(J)*LT(I,J))	SMT
1916	750	CONTINUE	SMT
1917		BHAT(I)=(WY(I)-SUM)/LT(I,I)	SMT
1918	800	CONTINUE	SMT
1919	C	TT	SMT
1920	C		SMT
1921		DO 950 I=1,4	SMT
1922		B(I)=SNGL(BHAT(I))	SMT
1923	C	WRITE (6,900)BHAT(I),B(I)	SMT
1924	950	CONTINUE	SMT
1925	900	FORMAT (1X,'BHAT ',F30.15,'BSNGL ',F30.15)	SMT
1926	C		SMT
1927		RETURN	SMT
1928		END	SMT
1929	C		SMT
1930	C	***** MATRIX MULTIPLICATION XT * X = XRES *****	SMT
1931	C		SMT
1932		SUBROUTINE MATSQ (X, XRES, M, N)	SMT
1933		REAL*8 X(8,7),XT(7,8),XRES(7,7),SUM	SMT
1934	C		SMT
1935	C	*** BUILD X-TRANSPOSE IN LT *****	SMT

1936	DO 20 I=1,M	SMT
1937	DO 10 J=1,N	SMT
1938	XT(J,I)=X(I,J)	SMT
1939	10 CONTINUE	SMT
1940	20 CONTINUE	SMT
1941	C	SMT
1942	C *** XT * X = XRES ****	SMT
1943	C	SMT
1944	DO 50 I=1,N	SMT
1945	DO 40 J=1,N	SMT
1946	SUM=0.0D0	SMT
1947	DO 30 K=1,M	SMT
1948	SUM=SUM+(XT(I,K)*X(K,J))	SMT
1949	30 CONTINUE	SMT
1950	XRES (I,J) = SUM	SMT
1951	40 CONTINUE	SMT
1952	50 CONTINUE	SMT
1953	RETURN	SMT
1954	END	SMT
1955	C	SMT
1956	C **** MATRIX MULTIPLICATION XT * Y = XTY ****	SMT
1957	C	SMT
1958	SUBROUTINE MATMUL (X,Y,XTY,M,N)	SMT
1959	REAL*8 Y(8),XT(7,8),X(8,7),XTY(7),SUM	SMT
1960	C TTTT TEST *****	SMT
1961	C	SMT
1962	C WRITE(6,102)	SMT
1963	102 FORMAT (1X,' Y ',/)	SMT
1964	C WRITE (6,100)(Y(I),I=1,8)	SMT
1965	100 FORMAT (1X,6F20.10)	SMT
1966	C WRITE(6,101)	SMT
1967	101 FORMAT (1X,' X ',/)	SMT
1968	DO 150 I=1,8	SMT
1969	C WRITE (6,100)(X(I,J),J=1,7)	SMT
1970	150 CONTINUE	SMT
1971	C	SMT
1972	C ???	SMT
1973	C	SMT
1974	C	SMT
1975	C **** BUILD XT ****	SMT
1976	DO 20 I=1,M	SMT
1977	DO 10 J=1,N	SMT
1978	XT(J,I)=X(I,J)	SMT
1979	10 CONTINUE	SMT
1980	20 CONTINUE	SMT
1981	C	SMT
1982	C **** XT * Y = XTY ****	SMT
1983	C	SMT
1984	DO 50 I=1,N	SMT
1985	SUM=0.0D0	SMT
1986	DO 40 J=1,M	SMT
1987	SUM=SUM+(XT(I,J)*Y(J))	SMT
1988	40 CONTINUE	SMT
1989	XTY(I)=SUM	SMT
1990	50 CONTINUE	SMT

1991		RETURN	SMT
1992		END	SMT
1993	C	*****	SMT
1994		SUBROUTINE SORT (Y,N)	SMT
1995	C	INPLACE SORT USING SHELL ALGORITHM *****	SMT
1996		REAL Y(N),TEMP	SMT
1997		INTEGER GAP	SMT
1998		LOGICAL EXCH	SMT
1999	C		SMT
2000		GAP=(N/2)	SMT
2001	5	IF (.NOT. (GAP.NE. 0)) GO TO 500	SMT
2002	10	CONTINUE	SMT
2003		EXCH=. TRUE.	SMT
2004		K=N-GAP	SMT
2005		DO 200 I=1,K	SMT
2006		KK=I+GAP	SMT
2007		IF(.NOT. (Y(I).GT.Y(KK))) GO TO 100	SMT
2008		TEMP=Y(I)	SMT
2009		Y(I)=Y(KK)	SMT
2010		Y(KK)=TEMP	SMT
2011		EXCH=. FALSE.	SMT
2012	100	CONTINUE	SMT
2013	200	CONTINUE	SMT
2014		IF (.NOT. (EXCH)) GO TO 10	SMT
2015		GAP=(GAP/2)	SMT
2016		GO TO 5	SMT
2017	500	CONTINUE	SMT
2018		RETURN	SMT
2019		END	SMT

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